The Dock & Harbour Authority

No. 383. Vol. XXXIII. SEPTEMBER, 1952 Monthly 2s. 0d

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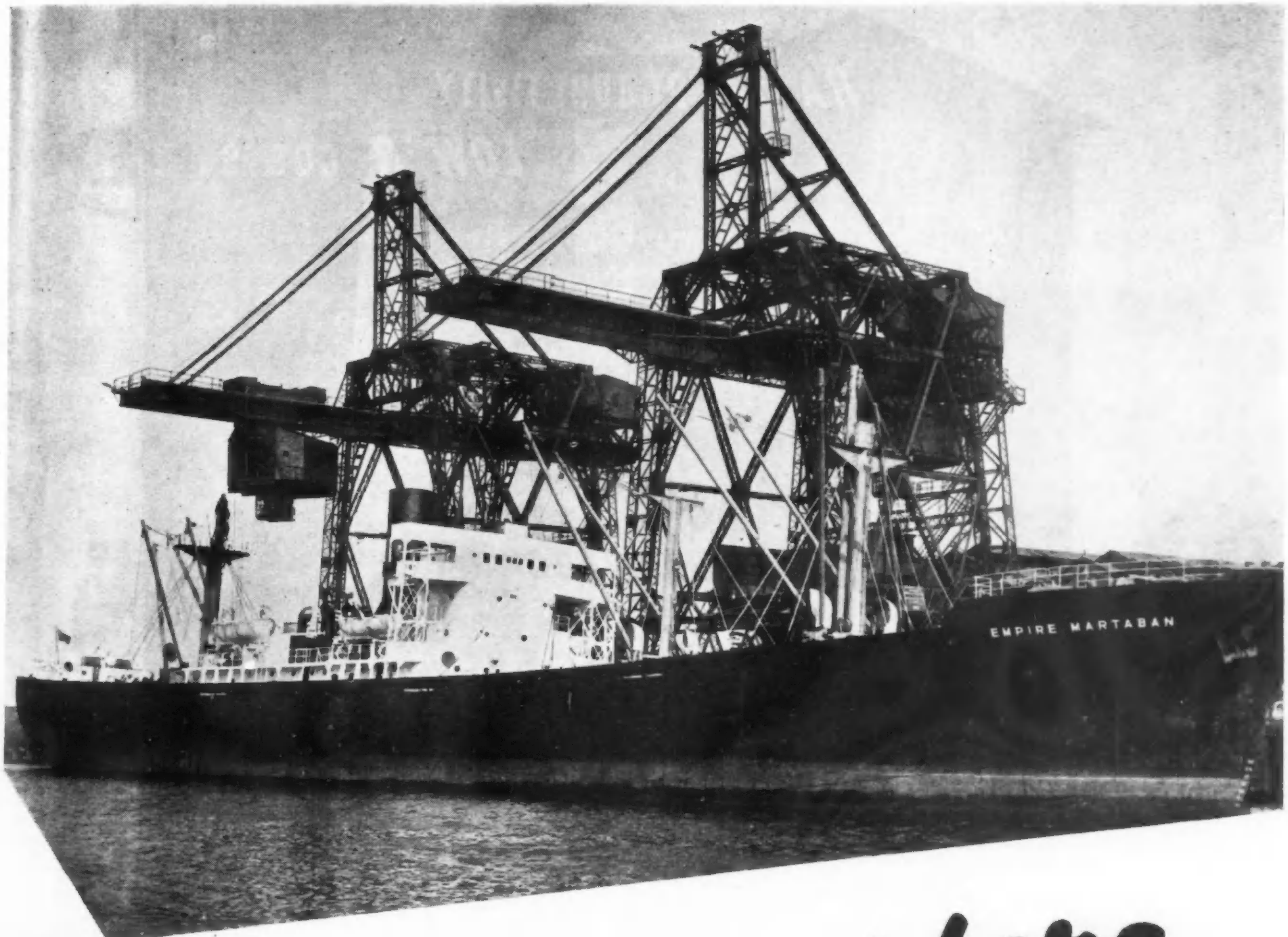
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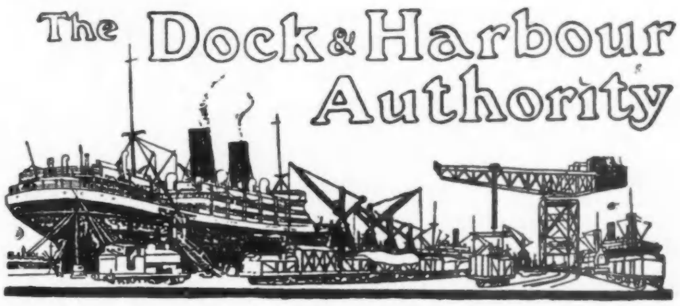

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The Dock and Harbour Authority

No. 383. Vol. XXXIII SEPTEMBER, 1952 Monthly 2s. 0d

Editorial Comments

The Port of London.

In this issue we are publishing an account of some engineering aspects of the post-war reconstruction and developments of the Port of London, and our readers will find much of interest in the modernisation methods adopted by the port's engineering staff. As the article by Mr. N. N. B. Ordman gives a description of the technical difficulties involved, there is no need to reiterate the various points he makes, but there are many aspects of the article which are worthy of careful study by those engaged in port operating and cargo handling.

In the first place, our overseas readers are probably unaware of—or at all events they do not fully appreciate—the extent of the damage and devastation caused to so many United Kingdom ports by enemy air-raids during the recent war. The Port of London was in the forefront of the Battle of Britain and suffered so badly that vast areas of transit sheds and other storage accommodation were completely destroyed, or so seriously damaged that major repairs were essential before they could again be brought into service. This has impaired the efficiency of the port ever since the conclusion of hostilities and has been one of the major causes of the slow turn-round of shipping and of delays in cargo handling.

As the author has pointed out in his article, the variety of reconstruction works are so extensive that he has only been able to give a brief description of some of them, but in addition he has put forward some cogent arguments concerning the need for careful planning and costing in connection with the lay-out and design of ports. In particular, he emphasises that modern mechanical handling aids involve the provision of stronger and more roomy buildings in order to cope with the additional loads. This, in turn, involves additional initial costs and subsequent maintenance costs —a factor which is perhaps not sufficiently considered by those who look to mechanisation for the solution of most cargo handling problems.

A readiness to adopt new methods and materials is shown in the new works and this is to be commended. Considering the shortage of materials and of labour for the work of new building and reconstruction which has been a feature of post-war conditions throughout the country, the progress that has been made by the engineering staff of the Port of London Authority is impressive. Also the steady increase in the volumes of imports and exports that have been handled each year, bear witness to the resolution and vigour with which the work of rehabilitation has been carried out.

The Loading of Cargo Ships.

The important influence of longitudinal distribution of cargo is the subject of a memorandum which was recently issued by the committee of Lloyd's Register of Shipping. The notice refers particularly to shelter deck cargo ships of about 9,000 to 10,000 tons deadweight and a length of about 400 to 430-ft., having large capacity deep tanks fitted amidships either forward of or abaft the machinery space.

In the fully loaded condition with cargo at a uniform rate of stowage throughout all spaces except the deep tanks, which are left empty, the longitudinal hogging moment is greater than if the cargo is stowed at a uniform rate throughout all spaces, including the deep tanks. Accumulating evidence from the Society's records indicates a significantly increased liability to main structural damage in heavy weather with the former distribution of loading.

The effect of this experience on individual ships is influenced by a number of factors which include design arrangements, size of deep tanks and additional scantlings provided.

The evidence referred to above, is based on confidential technical reports on ships registered with Lloyds which are submitted by the Society's surveyors, and the memorandum has been brought to the notice of owners and masters to assist them in ensuring judicious loading. The Society will be glad to give further guidance on specific ships to any owners who so request.

The loading of vessels which are destined for only one port of call is a comparatively simple proposition; it is when a vessel carries cargo for several destinations that the highest degree of ingenuity of the stevedores and master is called for. Any expert assistance and original technique gained as a result of collective enquiry would therefore be welcomed by all concerned, not only from the point of view of the safety of the ship, but also for easier unstowing and unloading, as both these operations have a profound influence on the speed of ship turn-round.

Penalties for Overloading.

In connection with the loading of vessels there also arises the question of overloading and the adequacy of the penalties that are at present in force when masters of ships are prosecuted for breaches of the regulations.

Early this year a question was raised in the House of Commons concerning this point, the Minister of Transport being asked whether he was aware that the maximum fine that could be imposed for overloading a ship was frequently less than the extra profit derived from the freight paid on the extra cargo, and whether steps could be taken to prevent those profits being made by breaking the law. In reply, it was pointed out that, during recent months, the Ministry of Transport had instituted a number of successful prosecutions, and as the maximum penalties for overloading were prescribed in the Merchant Shipping Safety and Load Line Conventions Act 1932, legislation would be required to change them.

Unfortunately, however, in many cases, the imposition of the maximum fines, does not deter masters from overloading, as the profits to be derived from this dangerous practice are frequently far in excess of the penalties imposed. Many instances are reported in the daily Press of masters of foreign ships being fined large amounts in British courts for overloading, but who still succeed in making substantial profits for their employers.

One example quoted in "The Journal of Commerce" concerned a master who was fined £100 plus an additional £100 for each inch

Editorial Comments—continued

the loadline was submerged, but who, nevertheless, made £5,000 extra profit on the trip. As our contemporary stated at the time, such fines are " quite inadequate in these times of high freight rates and large ships, especially tankers. The higher the freight and the greater the tons per inch immersion, the more profitable overloading can be, and in view of the fact that both freights and ship sizes are increasing, the greater the need becomes for bringing the Merchant Shipping Safety and Load Line Conventions Act of 20 years ago up-to-date as far as penalties for overloading are concerned."

South Wales Port Facilities.

On a following page will be found an article emphasising the need for better road communications to enable the ports of South Wales to take advantage of their favourable geographical position for dealing with cargoes from the West Midlands. This subject has been receiving increasing attention during recent months and representations have been made for Government action to be taken about the matter.

It has now been announced that the Industrial Association of Wales and Monmouthshire, in conjunction with the British Road Federation has convened a road transport conference which will be held at Cardiff on the 24th September to consider the increasingly serious problem of road communications serving South Wales and to decide what can be done to effect an improvement. The conference will also be attended by representatives of county and borough councils, local authorities and prominent industrialists to co-ordinate plans to alleviate the unsatisfactory conditions which are hampering the prosperity of the ports.

The importance of keeping open the small Welsh ports for the shipment of coal and other commodities has also been urged by the Wales Gas Consultative Council at Aberystwyth as the delivery of coal, and bulk cargoes, is cheaper by sea than by rail. In addition a survey of small Welsh ports is at present being made by the small seaports panel of the Council for Wales. The purpose is to see if they are capable of revival and extension, and can be used as an alternative to road and rail transport in the interest of industry and the tourist trade. The ports under review are Mostyn, Pwllheli, Caernarvon, Tenby and Cardigan.

We agree that the contribution that can be made by these smaller ports is only a part of the bigger question of the need for better road and rail facilities, but their claims to be included in any schemes that may be devised with a view to bringing more employment to the hinterland areas should be carefully considered. The progress of these meetings and representations to the Government will be watched with interest and it is to be hoped that, eventually, a satisfactory solution will be found.

Proposed Central Harbour Commission for New Zealand.

A report recently issued by a Royal Commission in New Zealand proposes that a Central Harbour Commission shall be established to plan the development of New Zealand's harbours to enable them to cope with changes and expansion in trade. The Royal Commission which was appointed two years ago to inquire into the waterfront industry, found that port accommodation and equipment was outdated.

Stressing the need for a more humane approach to the problem of industrial relations, the Report states that it is unfair to lay the whole blame for past port delays on the waterside workers. Good wages and conditions of employment and amenities at least equal to those in other industries are necessary. It also recommends that administrative control shall remain with the waterfront industry and that, in the meantime, the industry should stay outside the Arbitration Court under its own wage-fixing tribunal.

It is encouraging to learn from this Report that unreasonable strikes and stoppages have almost ceased, and that many malpractices in the labour field have been corrected following last year's strike which led to the registration of new wharf unions.

Another matter of interest is a proposal by the New Zealand Harbours Association that a conference of all the port authorities in Australasia shall be held in Auckland in 1954. The Australian Association has agreed in principle, but feels that further investigation is required before a final decision is reached. Meanwhile harbour boards are being asked to suggest subjects suitable for joint discussion.

Shipping Turnround at Commonwealth Ports.

The London Chamber of Commerce in its August Journal states that a great deal of useful work has been done in seeking the causes of delay in the turnround of shipping since the Congress of Empire Chambers of Commerce in London last year asked all its members to give this vital matter their attention.

" From the further information received an endeavour is made to reach a more accurate assessment of the problem . . . . In particular an excellent survey of the conditions in Hong Kong says that ' wharf and stevedoring labour in the port is hard working and efficient, and this factor, combined with the intelligent use of mechanised aids results in a speedy turnround of ships . . . it is significant that there has not been a single strike of wharf labour since the war.'

" Labour is clearly a big factor in efficient working, as may be seen by comparing the terms of this report with the evidence offered by the Associated Chambers of Commerce of New Zealand to the Royal Commission of inquiry into the waterfront industry. That evidence expressed the considered opinion that ' employer-employee relationship on a harmonious basis is really the only solution to many of the troubles experienced on the waterfronts.' The Associated Chambers' recommendations included a number of other points, but left no doubt that restrictive practices and slowing down of work were the main source of trouble.

" The dangers of generalising on the other hand, are illustrated by a special article in the journal of the Association of Chambers of Commerce of South Africa, which concludes that ' the advanced state of deterioration reached by ports in the Union is primarily due to the unequal union between harbours and railways which precludes the possibility of adequate harbour expenditure.' The solution suggested is a South African Harbour Authority as a semi-government concern which might provide progressive administration with harbour experts in control."

We are in complete agreement with the conclusions reached by the London Chamber that " it is desirable to assess at least roughly the extent to which each known cause is responsible for delay; in particular how much of the delay could be eliminated with the full co-operation of labour, and the removal of all restrictive practices. Provided that is known, the problem can be tackled rationally, but there cannot be whole-hearted concentration on the solution of their own problems while port authorities, wharfingers, merchants and transport undertakings doubt whether all they can do will affect more than a small part of the delay, and while port workers suspect that they are being blamed unfairly . . . . What is needed now is more knowledge of where responsibility rests and the goodwill to make use of it for the public good."

Frontier Talks between Holland and Germany.

Despite statements to the contrary, it has again been reported that preliminary Dutch-German discussions are in progress on the subject of certain frontier adjustments between those countries. According to these reports, the possibility is being studied of a new frontier arrangement for the Dollard Bay, which was claimed by Holland in 1947, and of a revision of the small border corrections carried out in 1949.

With regard to Dollard Bay, the Netherlands have never abandoned their demand for a frontier rectification, the reason being that this would render it possible to drain parts of the bay. Hitherto, Dutch wishes in this direction have encountered strong resistance on the part of harbour and industrial interests at Emden, who fear that the creation of a new polder might have a silting-up effect on their harbour entrance.

Further information concerning this project would be of undoubted interest, and it would appear that the problem as to whether the scheme would be detrimental to German interests would best be resolved by the construction of a hydraulic model, in which science the Dutch are well renowned.

The Port of London

Some Engineering Aspects of Post-war Reconstruction and Development

By N. N. B. ORDMAN, B.Sc., A.M.I.C.E.

THE Port of London Authority's undertaking extends from the Nore in the east to Teddington Weir in the west and covers 69 miles of river and five distinct groups of docks (Fig. 1). These dock groups contain in all 43 miles of quay enclosing just over 703 acres of water of which approximately 695 acres are impounded. In addition the Authority owns warehouses, cold stores, offices and other properties outside the the docks proper.

When it is considered that approximately one-quarter of the total transit shed accommodation and one-third of the above-ground storage accommodation were destroyed or seriously damaged by enemy action and that none of the dock groups escaped such damage, the scale of the task facing the Authority in its reconstruction programme will be realised.

The extent and variety of the reconstruction that has been undertaken by the engineering department under the Chief Engineer, Mr. W. P. Shepherd-Barron, M.C., T.D., M.Inst.C.E., M.Inst.Mech.E., are such that a comprehensive account cannot be given in one article. In this article, therefore, it is not proposed to describe in detail the many projects that have been completed or are in course of construction or planning. Indeed not all the projects will be mentioned. Instead an attempt will be made to set out certain aspects of planning, backed by illustrations from works which have either recently been completed or are under construction.

General Considerations Affecting Planning

At the outset, certain general considerations may be enunciated. In meeting the requirements of a complex and ever developing industry the engineer must provide adequate road and quay space, spacious and well-lit buildings and efficient equipment, all of which must be capable of standing up to exacting use over long periods with the minimum of maintenance. An important aspect of the engineer's task is thus to arrive at a sound balance between initial and maintenance costs having regard also to the fact that maintenance frequently interferes with operations and thus contains a hidden cost. Apart from the limits set by financial considerations, planning is circumscribed by the site conditions. In an intensely built-up area such as London (and this applies to most other major ports) the area available for development is restricted. Road, rail and water access to the dock estates are fixed and can rarely be materially altered. Foundation difficulties, although they can be overcome (often only at great expense) place limits on the height and permissible floor loadings of buildings.

Examples of Site Limitations

Limitations of the kind described above have been met with in all the dock groups, but are perhaps most restrictive in the London and St. Katharine Docks, which are nearest to the centre of London and are thus situated in an area where the surrounding property is not only dense but very valuable. These docks were opened in 1805 and, although improvements have been carried out from time to time, the road and quay widths are restrictive under modern conditions. To increase road and quay widths without reducing transit or warehouse space requires either an extension of the docks beyond their present boundaries or a vertical development. The latter possibility which will be referred to again raises the question of foundations.

An unusual feature of this dock group is the extensive system of vaults that underlies many of the buildings and some of the quays. These vaults, which are of barrel or groyned brick arch construction provide valuable storage for such commodities as wines and spirits (Fig. 2). Where a building overlying such vaults has been destroyed and the vaults left intact or repairable, obvious limitations are placed on the height and loading characteristics of a new building to be constructed over them.

Figs. 3 and 3a show a two-storey transit shed erected on the north side of Shadwell Basin in London Docks, where extension to the rear was not possible. In this case, there were no vaults under the site, and the foundations were piled. The site was not without foundation difficulties, however. A typical example of the difficulties encountered in built-up areas was the existence of a main sewer under the site. Fig. 4 shows the site prior to the war.

As can be seen the original building extended from the boundary wall to within a short distance of the quay. The new building allows for a wide road at the back and a wide quay. The single-

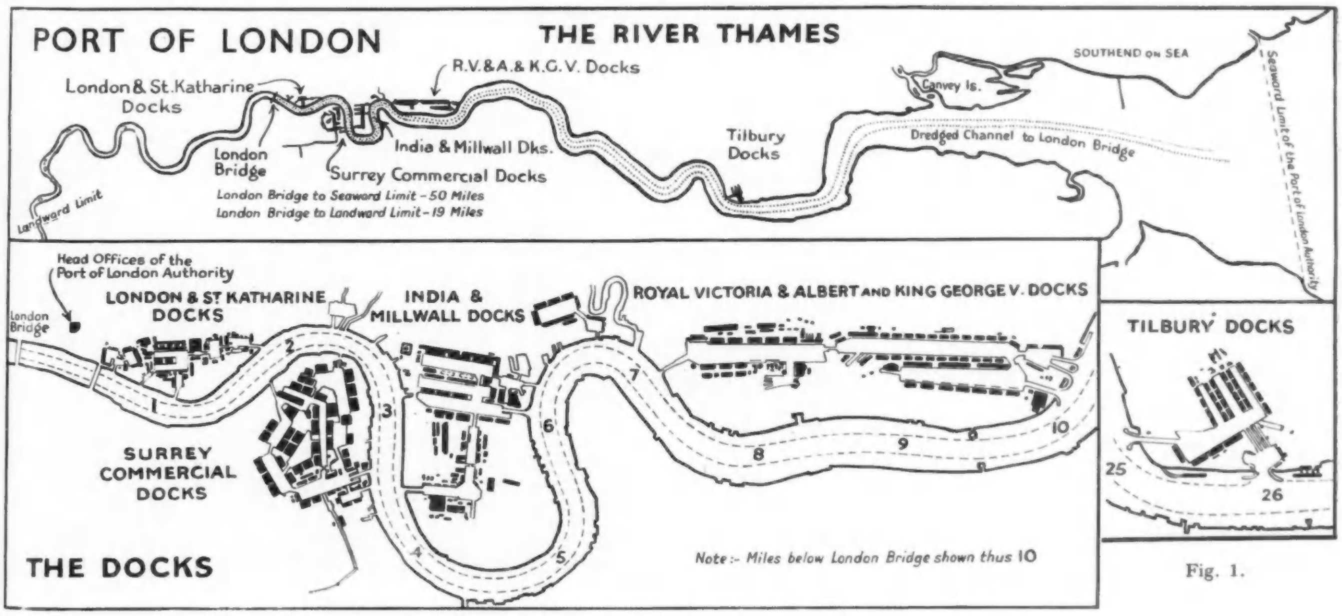


Fig. 1.

The Port of London – continued

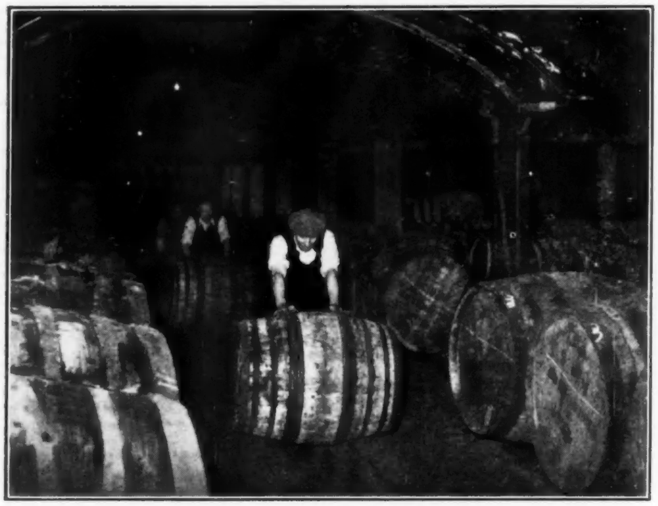


Fig. 2. Typical vault storage for wines and spirits in the London and St. Katharine Dock Group.

quays, stronger floors capable of supporting increased point loads from the wheels of cranes and trucks, and increased distributed loads resulting from higher stacking. The increased capital costs inherent in these requirements is a consideration not always remembered in assessing the economic advantages of the use of mechanical equipment.

No major improvements have occurred in the efficiency and speed of the more fundamental types of mechanical equipment used in ports, such as quay and wall cranes, lifts, and conveyors.

From the strictly engineering viewpoint an important difference between post and pre-war planning has been the shortage of certain materials, e.g. steel and timber, and the consequent development and use of materials such as pre-stressed concrete, and aluminium alloys, and structures such as box-pile jetties. There has also been a noticeable improvement in the specification and control of concrete. The most important change however, has been the rapid increase in building costs.

Examples of Post-War Reconstruction

Turning from general considerations to actual examples it will be convenient to divide the post-war reconstruction in the port into three classes, viz.:

(a) badly damaged structures repaired in the original form of construction or nearly so.

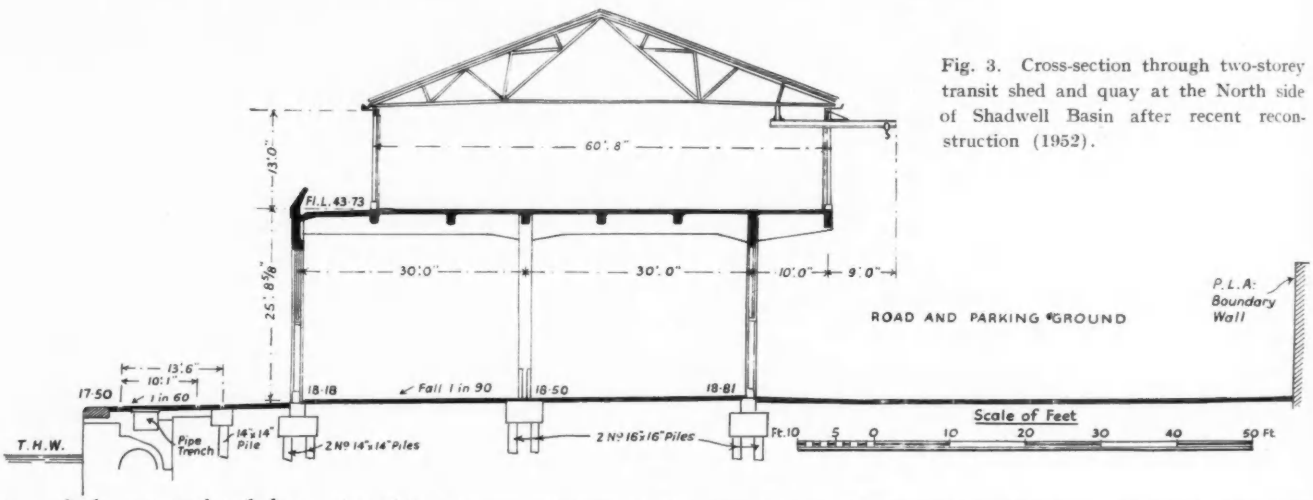


Fig. 3. Cross-section through two-storey transit shed and quay at the North side of Shadwell Basin after recent reconstruction (1952).

storey sheds are replaced by a two-storey building, providing an example of the development in height mentioned earlier.

Post-War Compared with Pre-War Planning

There are no major differences between the general lines governing post-war planning and those which occurred before the war, except of course in the greatly increased scope presented in the former. Tendencies plainly discernible before the war are continued but are perhaps more strongly accentuated in certain cases. An important pre-war trend which shows signs of continuing is the increase of road transport as compared with rail. Resulting from this and particularly important from the engineer's point of view are the increasing size, weight and height of vehicles and their loads. This trend must be reflected in wider and stronger roads, quays and bridges.

Another important development is the increased use of certain types of mechanical handling equipment mainly mechanised trucks in place of hand trucks, fork-lift trucks and mobile cranes. Translated into structural requirements this means greater headroom in buildings, wider and higher doors, wider

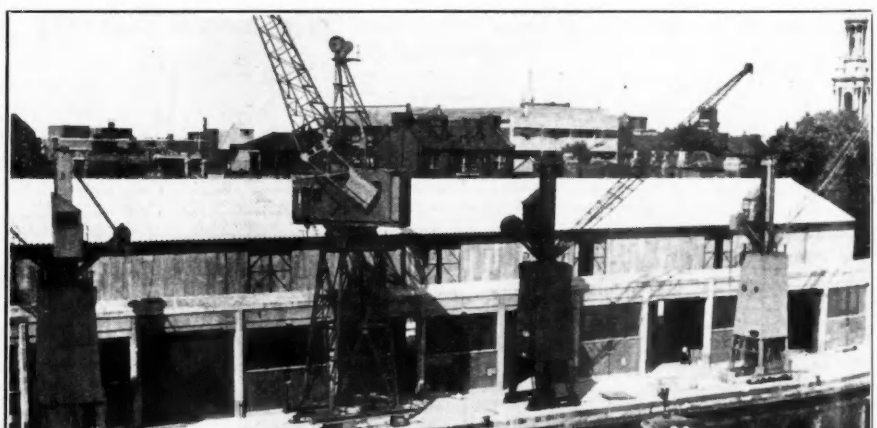


Fig. 3a. Elevation of two-storey transit shed illustrated in Fig. 3. Note electric and hydraulic cranes operating on same quay on tracks of different gauge.

The Port of London—continued

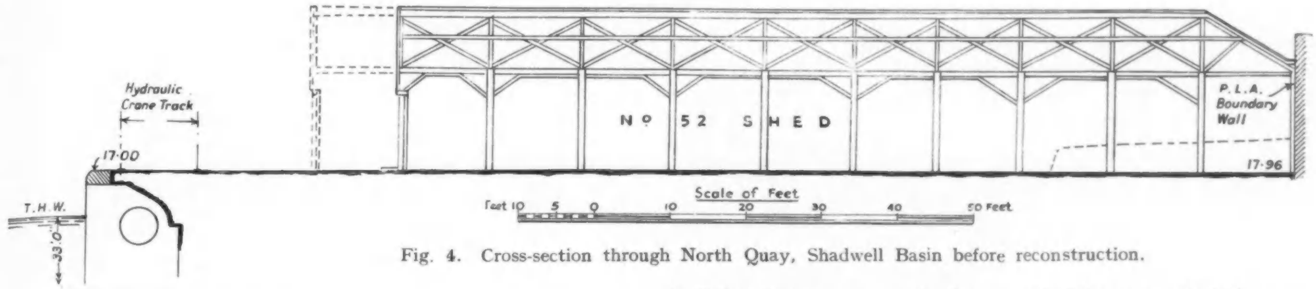


Fig. 4. Cross-section through North Quay, Shadwell Basin before reconstruction.

Fig. 5. The corner of the building in the foreground was destroyed by a bomb. Rebuilding in the original form of construction, i.e. with load-bearing walls was found to be cheaper than the introduction of steel or concrete framework. To the left of the picture is seen the reconstruction in reinforced concrete of a complete wing of the warehouse.

(b) structures completely demolished and rebuilt to the same dimensions as the original structure, but in different form of construction.

(c) areas where the damage has been so severe and extensive that the replanning of the whole area is possible.

(a) Major Repairs

Under class (a) may be listed major repairs. The buildings mostly concerned are brick buildings with timber floors and load-bearing walls (some of which are over a hundred years old) and steel-framed, single-storey buildings with corrugated steel or zinc sheeted roofs and sides. Reinforced concrete-framed buildings, quays and jetties suffered very little damage. In the case of badly damaged buildings, particularly when they are old, the engineer is faced with a difficult problem in deciding whether to recommend their repair or complete demolition and reconstruction. The problem is complicated by the fact that in a bomb damaged building serious damage may be hidden and can be revealed and assessed only after further demolition or extensive excavation. Financial considerations must take into account the improved facilities that can generally be provided in a new building.

Fig. 5 shows a brick building with load-bearing walls and timber floors, the corner of which was demolished by a bomb. The introduction of steel work to reduce the volume of brickwork in the reconstruction was considered and found to be less economical than rebuilding in the original form of construction, despite the fact that the brick walls at the base were 4-ft. 6-in. thick.

Badly damaged timber floors have in a number of cases been replaced by reinforced concrete beam and slab construction, and timber-slated roofs by conventional steel trusses and asbestos cement sheeting. In a building of this class which was completely gutted leaving only the outer walls standing and structurally sound, a reinforced concrete structure has been built up inside the outer shell. Fig. 6 shows the treatment of a single-storey warehouse; the original timber slated roof has been replaced by welded steel portals and asbestos sheeting with internal lining to give it an appearance in keeping with its use as a canteen.

The steel-framed buildings which were damaged were nearly all of one storey; either of the lofty type associated with timber storage or the lower type used as general cargo transit sheds. Fig. 7 illustrates a typical timber shed at Surrey Commercial Docks. The seven bays, each span 57-ft. 6-in., the length is 152-ft. 9-in. and the clear height is 33-ft. These sheds were rebuilt to the original design, except that 18 gauge galvanised corrugated steel sheeting generally replaced damaged zinc sheets because of the high cost and shortage of the latter. It should be noted that some of the zinc sheeting had lasted thirty years without requiring attention. The only change in structural design has been the respacing of purlins and sheeting rails as necessary to suit the new type of sheets.

Fig. 8 is a cross-section through a typical steel-framed transit shed of which there are seven on the south side of the King George V Dock. Their width is 120 feet and their length varies from 520 to 540 feet. The clear height to the underside of the principal ties of the trusses was 13-ft. 10½-in. Certain of these sheds were damaged and in considering their repair it was decided to increase the headroom by 4-ft. 6-in. to facilitate the use of mechanical handling equipment within the shed. This decision was prompted partly by the fact that the sheds were due for major sheeting repairs which reduced the additional work that would otherwise have been required to raise them. The method of increasing the headroom was to remove the sheeting, expose the column bases, release the columns from their base plates, jack them up and weld on extension pieces. The columns were then bolted down to the base plates and the sheds resheeted.

(b) Rebuilding in a Different Form of Construction

An example of the second class of reconstruction is illustrated in Fig. 9. A large section of No. 10 Warehouse in London Docks was destroyed by fire. Site conditions were such that the area occupied by the original building could not be extended. The new section has thus approximately the same dimensions as the old, but is of entirely different construction. The original structure had load-bearing brick walls and timber floors with cast-iron columns. The permissible floor loading is 1½ cwt. per square foot. The new section has a reinforced concrete framework with brick panel walls, no attempt having been made to match the new section with the old. A feature of the panel walls is that they consist of two 4½ inch skins tied together with brick reinforcement. The outer skin is of facing bricks, and the inner of sand lime bricks. This is designed to give a light interior without the need to paint the internal faces of the walls. It has the additional

The Port of London—continued

Fig. 6. Industrial canteen, London Docks, formerly a warehouse with timber trusses and slated roof.

226,800 square feet. They have formed the pattern for current warehouse construction in the port.

The light-coloured internal brick lining used in the latest warehouses has already been mentioned. Large window areas are provided to produce the maximum natural lighting, and internal faces of columns and beams and the soffits of floor slabs etc. are distempered white. Electric light and power conduits are buried in the concrete construction. This is done partly to obviate any dark crevices which might promote the growth of insects or bacteria. The warehouses are equipped with electric goods lifts which can accommodate loaded electric trucks, and also with electric wall cranes.

Single-storey transit sheds have been constructed hitherto of steelwork with corrugated steel sheeted walls and roofs, and spans up to 60 feet, utilizing conventional roof trusses. This form of construction has many advantages amongst which are speed of construction, low initial cost and easy repair. The conventional steel roof truss is still the most economical method of providing moderately large span roofs. However, this type of transit shed construction has certain disadvantages e.g. the large area to be painted, leading to high maintenance costs and the restriction in headroom caused by the bottom tie of the truss. The latter disadvantage may be eliminated in several ways, one of which is by

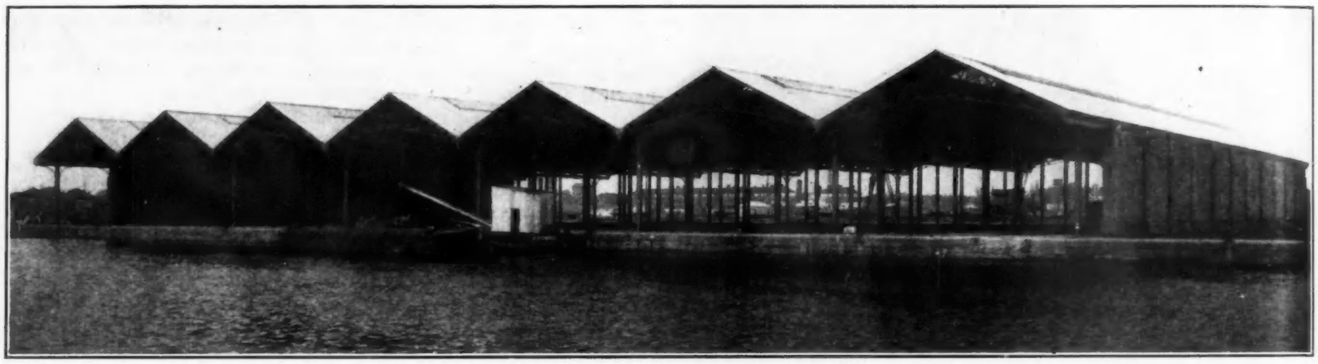


Fig. 7. Typical timber storage shed, Surrey Commercial Docks.

advantage that both faces of the walls are fair faced. The floor loading in the new section is 4 cwt. per square foot on the ground floor, and 1½ cwts per square foot on the other three floors.

Fig. 10 which shows the ground floor of the new section is another example of the increased headroom referred to earlier. The clear headroom is 19-ft. 6-in. as compared with 9-ft. in the original building. To accomplish this the first floor of the new section was made to correspond to the second floor of the old section.

The fact that large warehouses are divided into sections by fire-walls has frequently resulted in one or more divisions being destroyed and the remaining divisions being left comparatively undamaged. Thus the method of reconstruction used in No. 10 Warehouse as described above is being used in other similar cases.

Materials and Construction

Before proceeding to a consideration of the third type of reconstruction some general remarks on the materials used and the types of construction adopted may not be out of place. Multi-storey warehouses, both in the years immediately before the war and after it have invariably been of reinforced concrete framed construction with brick panel walls. Apart from considerations of economy and robustness, this form of construction requires comparatively little maintenance. Reinforced concrete buildings erected in the docks approximately forty years ago now require considerable repairs due to concrete flaking off and exposing the reinforcement. Close attention is now being given to providing adequate cover and obtaining a dense, well-compacted concrete free from honeycombing, and it is considered that the modern buildings will have long trouble-free lives.

The largest buildings of this type in the port are the five warehouses on the north quay of the Royal Victoria Dock. These warehouses are four stories high and each has a floor area of

the adoption of a portal type of construction, and the former by using a type of sheeting which does not require painting or requires less frequent painting than galvanised steel sheets. Such methods have been or are being tried by the Authority.

Types of Cladding

Asbestos-cement sheeting is satisfactory where it cannot be damaged by cranes or is not ruled out for reasons of security. Due to its comparative frangibility it is not suitable under dock conditions for side sheeting particularly below a height of six feet or so above ground. Steel sheets with protective coating have been widely used. They have a comparatively high initial cost and suffer from the disadvantage that if the continuity of the protective coating has been broken in cutting or fixing and has not been effectively re-sealed, corrosion may attack the metal and yet remain hidden from view. Provided that this is avoided, these sheets have a long life with low maintenance costs.

In transit sheds, lighting is an important factor. A highly reflective ceiling improves natural lighting and the efficiency of artificial lighting. The protective coating usually has a high bitumen content and is thus naturally dark. Sheets may now be obtained coated with aluminium paint, or an aluminium paint with a bituminous base may be supplied after fixing. This has been tried by the Authority but insufficient time has as yet elapsed to test the lasting qualities of the paint.

Aluminium Alloy Sheeting

Aluminium alloy sheeting is also being used. It is too early to assess its lasting qualities, but certain factors governing its use can be stated. The maker's expert advice is essential regarding the choice of alloy to be used. This is governed by the nature of the corrosive elements in the atmosphere to which the sheets will be subjected. Measures must be taken to prevent electrolytic action which may result if the alloy is allowed to come into

The Port of London—continued

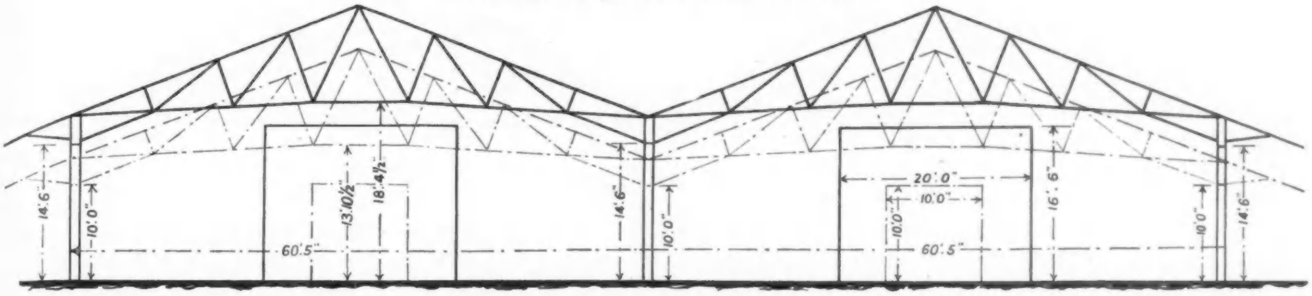


Fig. 8. Diagrammatic cross-section through typical transit shed on the South Quay, King George V Dock. The heavy lines show the leading dimensions after raising; the original dimensions are shown by broken lines.

direct contact with steel. The steel must either be galvanised or coated with bituminous paint. Special care must be taken in the fixing of power lines in the vicinity.

The great advantage of aluminium alloy sheeting is, of course, its high strength to weight ratio, and this advantage is most effective where the sheeting is part of the original design. The sheeting soon loses its original sheen if left untreated, but the optimum treatment and the frequency with which it will require to be repeated have not yet been established under dock conditions. Despite its comparatively high initial cost, aluminium alloy is an attractive material, and its use for sheeting and other purposes, although in its early stages, undoubtedly has wide possibilities.

Reinforced concrete shell roof construction has not, as yet, been used in London Docks. It lends itself to factory rather than dock construction, but it offers so many architectural advantages that it may well be adopted for dock use before long.

The ubiquitous brick should not be forgotten. For transit sheds, a steel or reinforced concrete framework with brick panel walls offers many advantages over any other form of construction in robustness and low maintenance costs and these may well outweigh the higher initial cost and longer construction period.

Damage to Buildings

Of all the buildings in a dock undertaking, transit sheds are most liable to damage. Particularly vulnerable and therefore costly in maintenance are doors, eaves, gutters and rainwater pipes. The author considers that top-hung sliding doors with bottom guides, fixed on the inside face of perimeter walls give the least trouble. The larger the door, the more costly and lengthy are repairs and this is a factor that should be borne in mind in considering the optimum height of a transit shed. Where possible rain-water pipes should be incorporated in concrete columns or against the webs of steel stanchions. If this is impossible they should be protected whether fitted internally or externally. It is the practice in the P.L.A. for eaves gutters in exposed positions to be protected by sturdy barge boards fixed on brackets independent from the gutter.

Damage to buildings and installations due to normal traffic and handling of goods appears to have become more extensive since the war. This is no doubt partly due to the increased use of mechanical equipment. Whatever the cause, the result is heavier capital expenditure in initial construction and increased maintenance costs. Not only are building costs increased by the installation of obvious protective measures such as guards to column angles, windows, rain-water pipes and gutters etc., but frequently heavier sections must be used than are required for purely structural reasons.

The problem does not end here because damage to buildings implies reciprocal damage to the packages or vehicles involved, resulting in a need for more robust (and thus more expensive) crating and vehicles. In turn this means heavier crates and machines, increased floor-loading, freight costs, and so on. The reduction of "incidental damage" is a problem that must be faced by those responsible for dock operating. It will not be solved entirely by improved layouts, although this is one obvious avenue of approach.

Improved Layouts

In post-war reconstruction improved layout planning is possible only where the extent of the war damage has been such as to provide a suitable area, which brings us to the third category of reconstruction mentioned earlier. Many aspects of this subject have been dealt with in articles printed in this journal. This discussion will be confined to those aspects which have been predominant in planning specific projects. Such planning, of course, calls for the intimate co-operation of the operating and engineering departments throughout, but the assessment of the basic requirements, which is frequently the most difficult single problem involved, is primarily the province of the former. The author may, however, be permitted some general observations on this problem.

The life-blood of a port is trade, and the port is affected by all the vicissitudes that beset trade. In these days of rapid changes, long-term assessments regarding specific commodities are surely hazardous. Who can tell how the development of artificial fibres will affect the wool trade, for example, or to what extent air transport will encroach on sea passenger transport? Dock structures and installations, to fulfil their function, must be unusually robust, and are thus long-lived. Their high cost necessitates their continued use even when their efficiency has been considerably reduced. These considerations resolve into two specific problems for the engineer. Firstly, should he or can he design his structure with a certain limited life in view and, if so, what should that life be? Secondly, when called on to provide facilities for a specific commodity, should he design a layout suitable for general purposes with additional specific facilities that can easily be removed when the special requirement no longer exists, even if this entails reduced efficiency? The answer to the second question would appear to be in the affirmative except for certain com-

Fig. 9. Section of a warehouse destroyed by fire, rebuilt in reinforced concrete with brick panel walls. Original construction can be seen on right of photograph.

The Port of London—continued

Fig. 10. Interior view of ground floor of warehouse shown in Fig. 9, showing high headroom provided to enable mobile cranes to operate within warehouse, and economy achieved by high stacking.

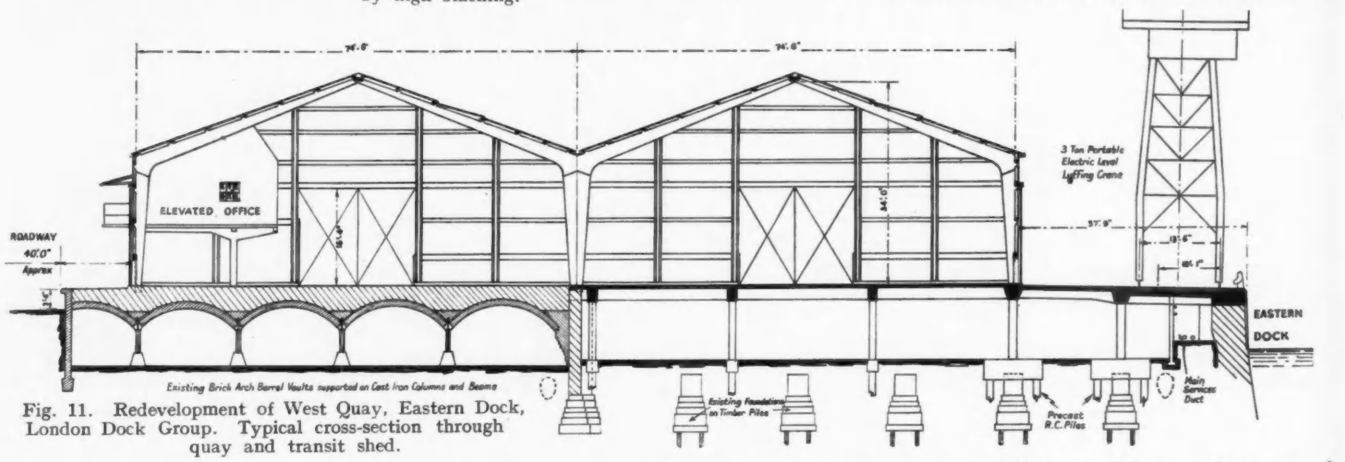


Fig. 11. Redevelopment of West Quay, Eastern Dock, London Dock Group. Typical cross-section through quay and transit shed.

modities such as grain, metal ores etc. The first problem is much less easily answered, and its ramifications are such that it might well form the subject of a separate article.

Effect of Increase in Road Transport

Apart from the greater use of mechanical handling equipment, the most important factor governing the layout of quays, buildings, etc., is the increase in road traffic at the expense of rail traffic together with the increase in weight and size of road vehicles. These developments require wider roads and quays and more and larger parking areas. Where the site is restricted these can be provided only at the expense of building plan area; i.e., the actual ground area occupied by the buildings must be reduced. The floor area of the buildings can, however, be maintained by two methods; firstly, by building two (or even three) storey sheds and secondly, by removing from the ground as far as possible, all ancillary buildings such as traffic and customs offices and latrines. It is sometimes an economic possibility to obtain increased road and quay area by an encroachment on the water area. This method has been used in the development now under construction of the south quay of the Import Dock, in the West India Dock Group. The increased quay width has been obtained by constructing a "false" quay in front of an existing quay wall, the "encroachment" amounting to approximately 24-ft.

In the reconstruction of the north quay of Shadwell Basin, in the London Dock Group, which has been referred to earlier (Figs. 3 and 4), the ground area could not be extended due to the proximity of the dock boundary wall.

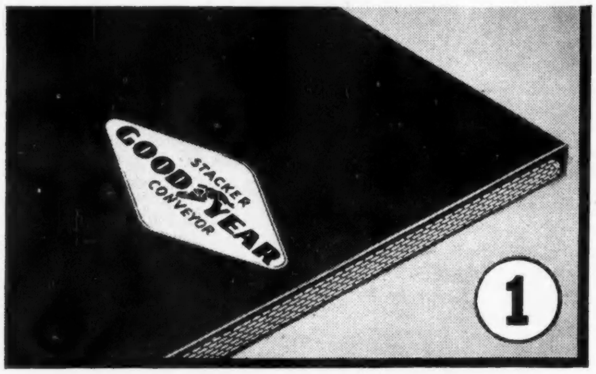
In this scheme, space has been obtained for an adequately wide roadway at the back of the shed by restricting the width of the shed to 60-ft. and making it two storeys high. The ground floor is of reinforced concrete with brick panel walls, and the upper storey is steel framed with corrugated steel sheeting to roof and sides.

A 10-ft. wide balcony is provided on the quayside, on to which sets are landed by the quay cranes. In order to preserve the width of the upper floor it is cantilevered out over the road at the back of the shed. This arrangement also allows lorries to be loaded from or discharged to the top floor while standing clear of lorries being dealt with on the ground floor. The clear headroom in the ground floor is 22-ft. 8-in. to allow mobile cranes to work within the shed. Due to the site conditions it was not possible to provide a loading bank at the rear of the shed and the use of cranes, etc., for loading and unloading vehicles will be very extensive.

The redevelopment of the west quay of the Eastern Dock in the London Dock Group which is at present being carried out, has several very unusual features of which only a brief description can be given here. The scheme consists essentially of a single storey transit shed 150-ft. wide in two spans of 75-ft., built entirely over vaults which extend right up to the quay wall. Figure 11 is a cross-section through the site. For reasons discussed earlier, portal frames have been adopted and to reduce steel requirements these, together with the purlins and sheeting rails, are to be of pre-stressed concrete. The sheeting for roof and sides (above a height of 5-ft.) is to be of aluminium alloy. The bottom 5-ft. of the walls are in brickwork. It is expected that this form of construction will prove economical in maintenance. The height to the eaves is 20-ft. The vaults on the east side of the site were destroyed and have been rebuilt in reinforced concrete. Access to the vaults is by hatches in the quay and the loading bank. A large service duct runs under the whole length of the quay in which are the fresh water, hydraulic, gas and electric mains.

It has been found possible in this scheme to keep the quays, roads and yards practically clear of ancillary buildings. To this end a latrine has been built under the approach road to the site. The shed and customs offices are to be built on a mezzanine floor in the shed, the space below them being utilised for gear stores, customs lock-ups, etc.

(To be continued)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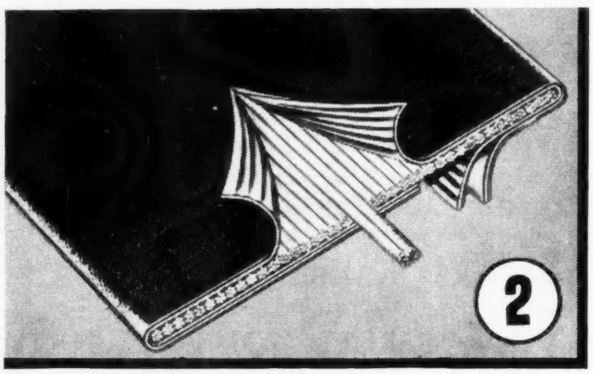
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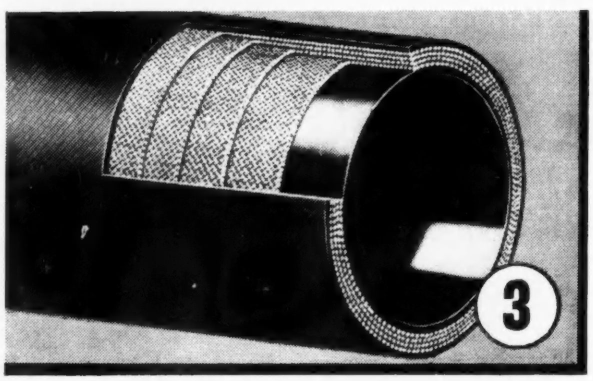

3

Resilient Wharf Fenders

Notes on Two New Systems for Berthing Large Vessels

By JOHS. NISSEN

Old Fashioned Fenders.

The increasing dead weight of modern vessels and the consequent enlargement of quay walls, raises a demand for heavier wharf equipment.

The fender system, which is attached for the purpose of protection of the wall as well as of the vessel, forms an essential part of any shipping berth.

The normal fender construction for small quay-walls, and in places with no tide, would be two or more horizontal timbers fixed to the front of the wall. Where tides cause the ship to rise and fall, it is usual, however, to construct the fender in the form of a number of vertical or raking piles, driven into the bottom in front of the quay face. Such piles usually timber piles—are resilient when deflected by a ship engaging one or more of them. The elastic resistance of the piles can be increased by placing heavy steel springs between the top of the piles and the front of the wall.

In some instances the piles are very heavy, up to 16-in. by 16-in. square, and they may be further strengthened by being assembled into groups containing two or four piles each.

For berths used by ships of the largest tonnage, this simple type of fenderwork is usually inadequate and must be replaced by heavy steel constructions fixed to strong steel piles, driven into the bottom.

The largest cargo vessels built to-day are tankers, and berths for tankers are usually placed separately from the ordinary cargo or passenger harbours and often at a place more exposed to waves than the basins of the main harbour. At such places, it is of great value to have strong resilient fenders which absorb the greater part of the kinetic energy of the vessels and thus prevent damage to the wall as well as to the vessels themselves.

The Ideal Fender.

The features required of the ideal fender are many and varied. Besides being able to absorb kinetic energy with gradually increasing resistance, the fender must be of a strong yet simple construction. Once erected, the fender should require no constant attention and only little maintenance. Besides absorbing the impact square to the quay, the fender must give way to forces parallel to the wall. It is only rarely that a ship moves parallel to the quay, but if the friction between the ship and the fender is too big, the surface of the fender will be damaged during such movement. The area of contact between the ship and the fender must not be too small. It can be a line, provided the line is at right angles to the direction of the frames of the ship. Previously, the frames of a ship were always vertical, but to-day they are often horizontal, especially in large vessels, making it difficult to meet this requirement. The fenders must be placed in such a manner that they can act at any state of the tide.

None of the previously designed fenders, whether fixed or resilient, comply with all the above-mentioned requirements, and it is doubtful whether such an ideal fender can be constructed at all.

The fenders described in the following paragraphs have recently been the subject of an application for a patent, for they have points of originality in their construction and their methods of absorbing energy.

Part of the Patent Specification.

In order that the invention may be clearly understood, some embodiments thereof will now be described, by way of example, with references to the accompanying diagrammatic drawings, in which :

Fig. 1 is a sectional elevation of a part of a berth and illustrates one form of fender according to the invention;

Fig. 2 is a plan on line II-II, Fig. 1;

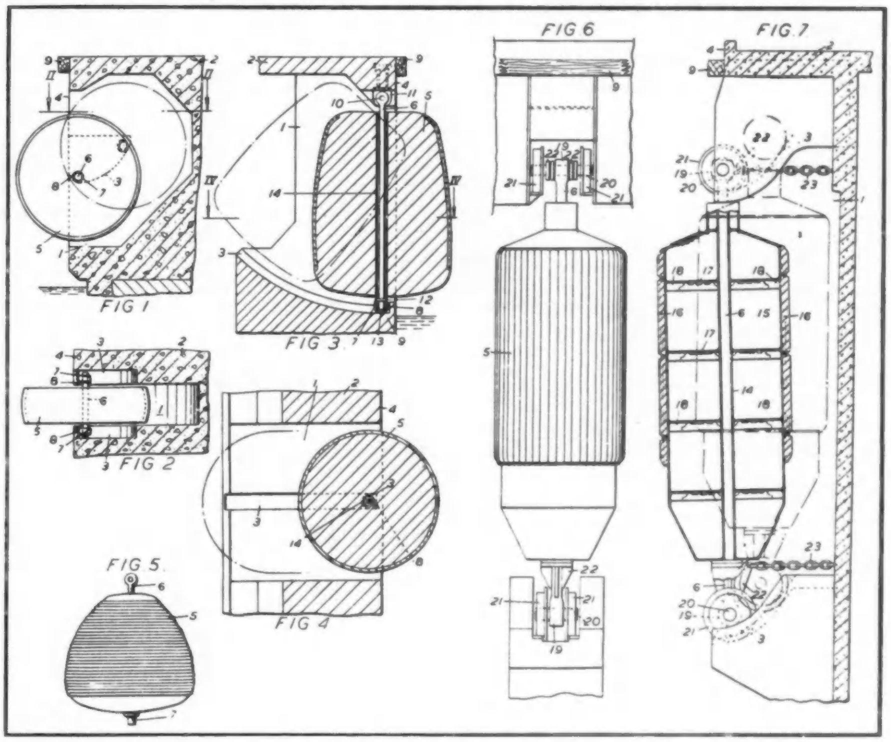
Fig. 3 is a sectional side elevation of another form of fender according to the invention;

Fig. 4 is a section on line IV-IV, Fig. 3;

Fig. 5 illustrates a fender of alternative shape to that shown in Fig. 3;

Fig. 6 is a front elevation of a further form of fender according to the invention; and

Fig. 7 is a side elevation, partly in section, of Fig. 6.



In the drawings like reference numerals refer to like or similar parts.

When a ship moves in towards the berth the side thereof engages the periphery of disc or cylinder (5) and the momentum of the ship absorbed by the weighted disc or cylinder, which is moved bodily upwards into the opening in the berth as the ship closes against the face thereof. During this bodily upward movement of the disc or cylinder (5) the sleeve bearings (7) rotate relatively to the axle (6) as the disc or cylinder is moved upwards along the upwardly directed guides (3). This upward movement causes the disc or cylinder (5) to roll on the side of the ship so that there is no rubbing action between the disc or cylinder and the side of the ship as the ship is being moored.

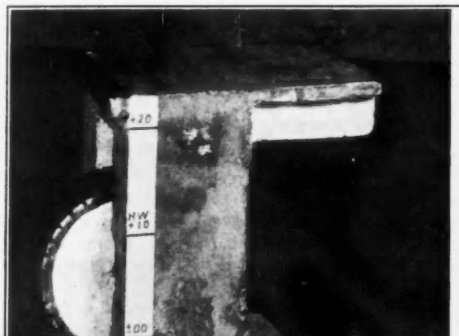
In order that the axle shall not be subjected to too great a pressure, the final impact of the ship is preferably absorbed by fixed fenders (9), which may be of wood or other suitable material and located adjacent the top of the berth.

When the ship is moored there is no sliding action between the ship and the fender formed by the disc or cylinder (5) in the type shown in Fig. 1, due to movement of the ship as a result of the rise and fall of the tide, because as the ship rises or falls the fender is rotated about its axis, the axle during this movement being rotated in the sleeve bearings (7), which remain stationary.

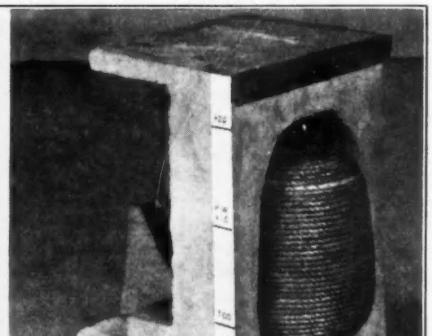
It will be understood that as the ship moves away from the berth both types of fender will descend along the guides (3) until again arrested by the abutments (8).

The peripheral surface of the disc or cylinder (5) which is engaged by a ship may be covered with steel, wood or rubber, or with any other suitable material.

Resilient Wharf Fenders—continued



Disc Fender.



Hanging Fender.

Fig. 5 is an alternative shape for a fender rotatable about a normally vertical axis and, as can be seen from the figure, the fender is of progressively increasing diameter from the top to the bottom thereof.

If desired, the sleeve bearing (7) may be fixed relatively to the support (6) and arranged to slide in the guide (3).

In Figs. 6 and 7 there is illustrated a fender whose axis remains substantially vertical at all times. In this embodiment of the invention the fender (5) comprises a steel cylinder (15) having wooden slats (16) secured to and extending lengthwise thereof. A sleeve (14) extends through the cylinder to house the support (6) and a plurality of strengthening diaphragms (17) are secured to the sleeve (14) and the cylinder. The diaphragms are provided with apertures (18) around its periphery and with further apertures, not shown, to facilitate the filling of the cylinder with sand or other suitable heavy material.

The support (6) has an eye (19) at each end through which pass horizontal axles (20) on each of which is mounted a pair of flanged rollers (21) co-operating with guides (3). Secured to the top and bottom of the cylinder (15 are anchor members (22) to which is anchored one end of each of a pair of chains (23). The other ends of the chains are anchored to the berth, which, in this instance, is represented by a breasting island, and when fully extended, as shown in Fig. 7, the chains locate the fender in its normal position.

The weighted fenders shown in Figs. 3 and 7 are substantially cylindrical in cross-section considered in a direction at right angles to the longitudinal axis thereof, but in preferred constructions the periphery of the fender is so shaped longitudinally as to be rounded towards the top and bottom thereof, as shown in the drawings, so that the side of a ship engaging the fender will nowhere rest against sharp edges or corners.

In operation, when a ship engages a fender, as described with reference to Figs. 3 to 7, with a given velocity the momentum of the ship is absorbed by the fender by one force which is at right angles to the berth and another force which is parallel thereto, but at a tangent to the fender. The fender will yield immediately to the first of these forces if, as shown in Figs 3 to 5, being swung bodily upwards about its pivot (10) in the manner of a pendulum, or being if, as shown in Figs 6 and 7, displaced bodily inwards and upwards while substantially maintaining its vertical position. When being so moved, the centre of gravity of the fender is moved upwards so that the fender due to its resistance against being lifted, exercises a counter-thrust against the side of the ship. The magnitude of this counter-thrust is determined solely by the weight of the fender and the distance through which it is moved.

The tangential force exerted on the fender by the ship causes a turning of the fender about its longitudinal axis, and this force is counteracted only to a slight degree by the fender and must primarily be absorbed by the moorings or by the propeller of the ship being berthed.

Since the fenders shown in Figs 1 to 7 are guided so as to be movable in one plane only, there is substantially no tendency for the fenders to swing during gales or heavy sea, even when no ship is berthed against the fenders. This feature is an improvement over the previously known types of swinging fender, as the known types must be moored during heavy seas so as not to suffer damage to themselves or to break the means by which they are suspended.

Fenders, according to the invention, may be disposed singly or arranged at regular intervals along the berth, or they may be disposed in groups arranged at spaced intervals along the length of the berth. Where the berth is provided in tidal waters, fenders as shown in Figs 1 to 5 may be provided at different heights in the face of the berth so that the rise and fall of smaller ships will not be hindered by the protrusion of the fenders from the face of the berth. Fenders as shown in Figs 6 and 7 can be made of such a length that the top is always above high water level and the bottom below low water level. It will be understood that as the fenders are to absorb the greater part of the momentum of a ship being berthed, the fenders for ships of greater and lesser tonnage will be of different weights and will, for heavy shipping, usually be of the order of several tons.

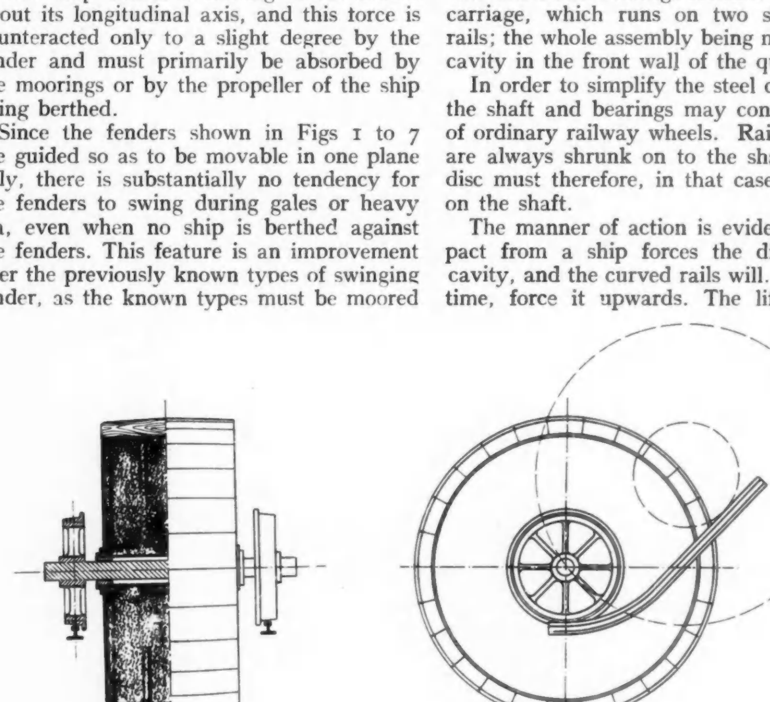
The manner of action and the construction of the fenders having been described in the foregoing, a short additional explanation of the advantages and disadvantages of each fender is given in the following :

The Disc Fender.

The first-mentioned fender consists of a heavy disc or cylinder mounted on a shaft provided with bearings or wheels at either end. If the disc is fitted to the shaft, the bearings or wheels must be able to revolve freely on the shaft, whereas, if the disc is revolving on the shaft, the bearings or wheels can be fixed to the shaft. The disc with shaft and bearings forms a two-wheeled carriage, which runs on two short curved rails; the whole assembly being mounted in a cavity in the front wall of the quay.

In order to simplify the steel construction, the shaft and bearings may consist of a set of ordinary railway wheels. Railway wheels are always shrunk on to the shaft, and the disc must therefore, in that case, run freely on the shaft.

The manner of action is evident. The impact from a ship forces the disc into the cavity, and the curved rails will, at the same time, force it upwards. The lifting of the



Disc Fender mounted on ordinary railway wheels.

Resilient Wharf Fenders—continued

discs requires energy, the amount of which is in direct ratio to the weight of the disc and the distance it has been lifted. While in movement, the disc turns a little in the opposite direction of the wheels or bearings. The disc must be of a suitable thickness, not less than 3-ft., so that it can always cover two frames of a ship, if these are placed vertically.

This fender, however, suffers the disadvantage that it does not give way to forces parallel to the quay, thus causing friction between the disc and the ship when the ship moves in that direction. These forces are determined by the pressure of the disc against the ship, and can therefore never increase to the same extent as in the case of a fixed fender, where the weight and speed of the ship determine the pressure.

The Hanging Fender.

The second fender is also of the rotating type, but it rotates on a normally vertical shaft which takes up a raking position when the fender is in action. The fender consists of a heavy bell-shaped body welded together of steel plates and provided with interior stiffeners. It is partly filled with ballast, sand, stone, or scrap, its centre of gravity being arranged as low as possible.

The guiding rail at the lower end of the shaft allows the fender to swing from a vertical position backwards into the cavity of the wall, but only in a plane square to the front of the quay.

When a ship touches the fender the impact will force the fender backwards like a pendulum, and due to the fact that the fender can rotate around its shaft, any movement of the ship in the direction of the quay will only cause the fender to revolve, so that no friction will arise between ship and fender. The curvature of the fender will cause it to roll on the side of the ship, vertically as well as horizontally.

When forced inwards, the centre of gravity of the fender moves upwards, thus absorbing an amount of energy which is in direct ratio to the weight of the fender and the distance it is lifted. Furthermore, the contact point between ship and fender moves upwards with the fender, causing the lever arm to shorten, thus further increasing the rate of energy absorption.

A disadvantage of this fender is the limitation of contact to a point of a curved, vertical line, and in the case of ships with vertical frames, this contact line may happen to be situated in the space between two frames.

In the alternative execution of the latter fender shown on the sketch on page 138, the vertical shaft of the weighted fender does not swing from a fixed bolt placed at its upper end, but is moved in such a manner that the fender keeps its vertical position, more or less, while lifted. This last fender may be built in lengths enabling it to reach from low water level to higher water, even in case of heavy tides.

The patent rights of these new fender devices are held by Messrs. Christiani and Nielsen Ltd., 54, Victoria Street, London.

Port Economics

Part 9. Competition and Co-ordination

By A. H. J. Bown, O.B.E., F.C.I.S., M.Inst.T.
General Manager and Clerk, River Wear Commissioners, and General Manager, Sunderland Corporation Quay.

WE have seen that the seaports of the world have arisen and have developed in their particular locations for some or all of the following reasons—natural harbour facilities, a good river, proximity to the ports of other lands across the sea, proximity to areas yielding primary products or the exportable proceeds of manufacture, density of population, the skill and industry of the citizens, the establishment of markets, and the activities of adventurous and able men having special aptitudes for seafaring, ship management, merchanting, banking and the construction of modern communications. One truth stands out above all others—the seeds of growth and the impulse to develop have always been local and peculiar to the place. One man, endowed with the necessary power, could stand, as it were, on an eminence in the middle of a country and plan its post offices—but he could not plan its ports because every port is a living, complex organism, born of and embodying the life and character of its neighbourhood, and no two ports are alike. That is not to say that, in our day, after 200 years of gradual port modernisation, it is impossible for one man or a group of men to survey the national—and even the international—port scene, to formulate some general principles, to apply some valid general tests and possibly to make suggestions for improving the vigour and efficiency of national port organisations.

In the United Kingdom, for example, ports have arisen at more than 300 places. Many of them, whilst mattering very much to their local communities, normally play no part in international commerce except insofar as they sometimes provide facilities for small coastwise vessels some of which work to or from ocean-going liners berthed at the larger ports. When the 1948 working party enquired into the turn-round of shipping, they paid some attention to 19 ports, namely, Bristol, Glasgow, Grangemouth, Bo'ness, Greenock, the Hartlepools, Hull, Leith, Liverpool, London, Manchester, Middlesbrough, Swansea, Cardiff, Newport, Port Talbot, Southampton, Newcastle-upon-Tyne, and Sunderland. To complete a rough list of U.K. ports with some substantial regular trade, we might add Aberdeen, Dundee, Ardrossan, Belfast, Blyth, Seaham Harbour, Grimsby, Immingham, Goole, Boston, King's Lynn, Ipswich, Harwich, Dover, Plymouth, Gloucester, Sharpness, Preston, Workington, Whitehaven and Maryport—making 40 in all.

The student of port economics is sometimes asked to consider how far these ports compete with one another, whether competition between them is a good thing or a bad one and whether it would be possible or desirable to regionalise or co-ordinate their activities by a superimposed national plan or by some other means. Let us first examine the economist's conception of competition and its counterpart, monopoly.

Competition and Monopoly.

In his "Introduction to Economics" (Butterworth & Co.), Alec Cairncross comments instructively on this matter. "A monopolist, we say, is selling something different from other people. But how different? Must the difference be as great as that between milk and tea, or can it be as small as that between milk from one farm and milk from another, or between one brand of tea and another? . . . If a single firm supplies us with 8 h.p. motor cars while other firms confine themselves to higher-powered cars, is the first firm a monopolist? The more we reflect, the more we are driven to conclude that practically every firm is in some sense a monopolist. . . . The fact is that we never find monopoly undiluted by competition, and very rarely find competition undiluted by monopoly. In most lines of business there is a blend of competition and monopoly in which the one or the other may preponderate. The difference between monopoly and competition is one of degree, not of kind."

Every port administrator knows the truth of this. If there was one port, and one only, in the United Kingdom that could accommodate ships above a certain size, that port would have a monopoly of the big-ship trade. If there were several such ports, they would share the monopoly, and the remaining ports would not be in it. But ships must carry cargo and/or passengers, some of which traffic may be drawn away from the big ships and be carried by

The Port of London—continued

Fig. 10. Interior view of ground floor of warehouse shown in Fig. 9, showing high headroom provided to enable mobile cranes to operate within warehouse, and economy achieved by high stacking.

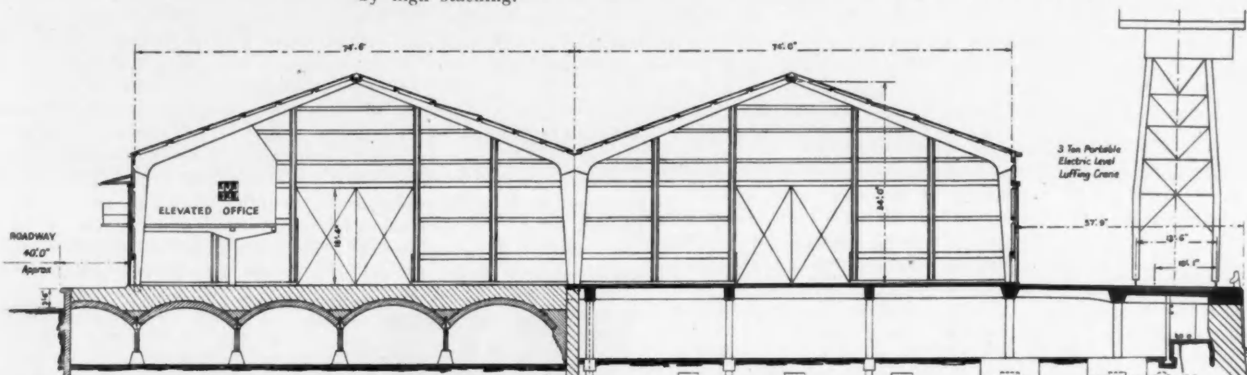


Fig. 11. Redevelopment of West Quay, Eastern Dock, London Dock Group. Typical cross-section through quay and transit shed.

modities such as grain, metal ores etc. The first problem is much less easily answered, and its ramifications are such that it might well form the subject of a separate article.

Effect of Increase in Road Transport

Apart from the greater use of mechanical handling equipment, the most important factor governing the layout of quays, buildings, etc., is the increase in road traffic at the expense of rail traffic together with the increase in weight and size of road vehicles. These developments require wider roads and quays and more and larger parking areas. Where the site is restricted these can be provided only at the expense of building plan area; i.e., the actual ground area occupied by the buildings must be reduced. The floor area of the buildings can, however, be maintained by two methods; firstly, by building two (or even three) storey sheds and secondly, by removing from the ground as far as possible, all ancillary buildings such as traffic and customs offices and latrines. It is sometimes an economic possibility to obtain increased road and quay area by an encroachment on the water area. This method has been used in the development now under construction of the south quay of the Import Dock, in the West India Dock Group. The increased quay width has been obtained by constructing a "false" quay in front of an existing quay wall, the "encroachment" amounting to approximately 24-ft.

In the reconstruction of the north quay of Shadwell Basin, in the London Dock Group, which has been referred to earlier (Figs. 3 and 4), the ground area could not be extended due to the proximity of the dock boundary wall.

In this scheme, space has been obtained for an adequately wide roadway at the back of the shed by restricting the width of the shed to 60-ft. and making it two storeys high. The ground floor is of reinforced concrete with brick panel walls, and the upper storey is steel framed with corrugated steel sheeting to roof and sides.

A 10-ft. wide balcony is provided on the quayside, on to which sets are landed by the quay cranes. In order to preserve the width of the upper floor it is cantilevered out over the road at the back of the shed. This arrangement also allows lorries to be loaded from or discharged to the top floor while standing clear of lorries being dealt with on the ground floor. The clear headroom in the ground floor is 22-ft. 8-in. to allow mobile cranes to work within the shed. Due to the site conditions it was not possible to provide a loading bank at the rear of the shed and the use of cranes, etc., for loading and unloading vehicles will be very extensive.

The redevelopment of the west quay of the Eastern Dock in the London Dock Group which is at present being carried out, has several very unusual features of which only a brief description can be given here. The scheme consists essentially of a single storey transit shed 150-ft. wide in two spans of 75-ft., built entirely over vaults which extend right up to the quay wall. Figure 11 is a cross-section through the site. For reasons discussed earlier, portal frames have been adopted and to reduce steel requirements these, together with the purlins and sheeting rails, are to be of pre-stressed concrete. The sheeting for roof and sides (above a height of 5-ft.) is to be of aluminium alloy. The bottom 5-ft. of the walls are in brickwork. It is expected that this form of construction will prove economical in maintenance. The height to the eaves is 20-ft. The vaults on the east side of the site were destroyed and have been rebuilt in reinforced concrete. Access to the vaults is by hatches in the quay and the loading bank. A large service duct runs under the whole length of the quay in which are the fresh water, hydraulic, gas and electric mains.

It has been found possible in this scheme to keep the quays, roads and yards practically clear of ancillary buildings. To this end a latrine has been built under the approach road to the site. The shed and customs offices are to be built on a mezzanine floor in the shed, the space below them being utilised for gear stores, customs lock-ups, etc.

(To be continued)

Resilient Wharf Fenders—continued

discs requires energy, the amount of which is in direct ratio to the weight of the disc and the distance it has been lifted. While in movement, the disc turns a little in the opposite direction of the wheels or bearings.

The disc must be of a suitable thickness, not less than 3-ft., so that it can always cover two frames of a ship, if these are placed vertically.

This fender, however, suffers the disadvantage that it does not give way to forces parallel to the quay, thus causing friction between the disc and the ship when the ship moves in that direction. These forces are determined by the pressure of the disc against the ship, and can therefore never increase to the same extent as in the case of a fixed fender, where the weight and speed of the ship determine the pressure.

The Hanging Fender.

The second fender is also of the rotating type, but it rotates on a normally vertical shaft which takes up a raking position when the fender is in action. The fender consists of a heavy bell-shaped body welded together of steel plates and provided with interior stiffeners. It is partly filled with ballast, sand, stone, or scrap, its centre of gravity being arranged as low as possible.

The guiding rail at the lower end of the shaft allows the fender to swing from a vertical position backwards into the cavity of the wall, but only in a plane square to the front of the quay.

When a ship touches the fender the impact will force the fender backwards like a pendulum, and due to the fact that the fender can rotate around its shaft, any movement of the ship in the direction of the quay will only cause the fender to revolve, so that no friction will arise between ship and fender. The curvature of the fender will cause it to roll on the side of the ship, vertically as well as horizontally.

When forced inwards, the centre of gravity of the fender moves upwards, thus absorbing an amount of energy which is in direct ratio to the weight of the fender and the distance it is lifted. Furthermore, the contact point between ship and fender moves upwards with the fender, causing the lever arm to shorten, thus further increasing the rate of energy absorption.

A disadvantage of this fender is the limitation of contact to a point of a curved, vertical line, and in the case of ships with vertical frames, this contact line may happen to be situated in the space between two frames.

In the alternative execution of the latter fender shown on the sketch on page 138, the vertical shaft of the weighted fender does not swing from a fixed bolt placed at its upper end, but is moved in such a manner that the fender keeps its vertical position, more or less, while lifted. This last fender may be built in lengths enabling it to reach from low water level to higher water, even in case of heavy tides.

The patent rights of these new fender devices are held by Messrs. Christiani and Nielsen Ltd., 54, Victoria Street, London.

Port Economics

Part 9. Competition and Co-ordination

By A. H. J. Bown, O.B.E., F.C.I.S., M.Inst.T.
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WE have seen that the seaports of the world have arisen and have developed in their particular locations for some or all of the following reasons—natural harbour facilities, a good river, proximity to the ports of other lands across the sea, proximity to areas yielding primary products or the exportable proceeds of manufacture, density of population, the skill and industry of the citizens, the establishment of markets, and the activities of adventurous and able men having special aptitudes for seafaring, ship management, merchanting, banking and the construction of modern communications. One truth stands out above all others—the seeds of growth and the impulse to develop have always been local and peculiar to the place. One man, endowed with the necessary power, could stand, as it were, on an eminence in the middle of a country and plan its post offices—but he could not plan its ports because every port is a living, complex organism, born of and embodying the life and character of its neighbourhood, and no two ports are alike. That is not to say that, in our day, after 200 years of gradual port modernisation, it is impossible for one man or a group of men to survey the national—and even the international—port scene, to formulate some general principles, to apply some valid general tests and possibly to make suggestions for improving the vigour and efficiency of national port organisations.

In the United Kingdom, for example, ports have arisen at more than 300 places. Many of them, whilst mattering very much to their local communities, normally play no part in international commerce except insofar as they sometimes provide facilities for small coastwise vessels some of which work to or from ocean-going liners berthed at the larger ports. When the 1948 working party enquired into the turn-round of shipping, they paid some attention to 19 ports, namely, Bristol, Glasgow, Grangemouth, Bo'ness, Greenock, the Hartlepools, Hull, Leith, Liverpool, London, Manchester, Middlesbrough, Swansea, Cardiff, Newport, Port Talbot, Southampton, Newcastle-upon-Tyne, and Sunderland. To complete a rough list of U.K. ports with some substantial regular trade, we might add Aberdeen, Dundee, Ardrossan, Belfast, Blyth, Seaham Harbour, Grimsby, Immingham, Goole, Boston, King's Lynn, Ipswich, Harwich, Dover, Plymouth, Gloucester, Sharpness, Preston, Workington, Whitehaven and Maryport—making 40 in all.

The student of port economics is sometimes asked to consider how far these ports compete with one another, whether competition between them is a good thing or a bad one and whether it would be possible or desirable to regionalise or co-ordinate their activities by a superimposed national plan or by some other means. Let us first examine the economist's conception of competition and its counterpart, monopoly.

Competition and Monopoly.

In his " Introduction to Economics " (Butterworth & Co.), Alec Cairncross comments instructively on this matter. " A monopolist, we say, is selling something different from other people. But how different? Must the difference be as great as that between milk and tea, or can it be as small as that between milk from one farm and milk from another, or between one brand of tea and another? . . . If a single firm supplies us with 8 h.p. motor cars while other firms confine themselves to higher-powered cars, is the first firm a monopolist? The more we reflect, the more we are driven to conclude that practically every firm is in some sense a monopolist. . . . The fact is that we never find monopoly undiluted by competition, and very rarely find competition undiluted by monopoly. In most lines of business there is a blend of competition and monopoly in which one or the other may preponderate. The difference between monopoly and competition is one of degree, not of kind."

Every port administrator knows the truth of this. If there was one port, and one only, in the United Kingdom that could accommodate ships above a certain size, that port would have a monopoly of the big-ship trade. If there were several such ports, they would share the monopoly, and the remaining ports would not be in it. But ships must carry cargo and/or passengers, some of which traffic may be drawn away from the big ships and be carried by

Port Economics—*continued*

smaller ships into smaller ports—that is to say, competition would be diluting the monopoly, which indeed it does. If there was only one port in England where a particular imported commodity could be advantageously marketed, cargoes from all exporting countries would be drawn to that port which would have a monopoly: but if that particular market is liable to periods of glut and if other markets, served by useful ports, are developed, then the traffic becomes decentralised—which, in fact, is the case with many imported commodities. Again, if a particular imported raw material is wanted in one area only, or in a few well-defined areas, and there are ports immediately serving such areas, the desired raw material will tend towards those ports provided they have the requisite facilities and the steamship services and provided also that there is no strong established market drawing the material to another port. Once more, if particular traffic demands expert handling or special quayside equipment if it is to be discharged, loaded or manipulated with complete success, it will tend towards the ports so provided and will only be seen at other ports in exceptional circumstances, such as periods of congestion or traffic dislocation. But, above all, there is a general tendency for the longest regular sea routes to be serviced by big ships, a second tendency for such ships to be owned and operated in fleets by the great shipowning companies, a third tendency for such companies to set up shore establishments at a limited number of the greatest ports, and a fourth tendency for those few ports to aim always at providing the accommodation required by the great ships. These four tendencies interweave to make the strongest strand in the whole complex network of the port and shipping industries. Taken together, they account for the routing of about 60% of the total volume of traffic at United Kingdom ports and they also account for the pre-eminence of London and Liverpool as general cargo ports and of Southampton as a passenger port. Broadly speaking, the other 37 ports (of the 40 mentioned earlier) share between them, in varying degrees, the remaining 40 per cent. of the nation's overseas trade.

Competition and Price.

The subject of port charges against ships and goods has been discussed in an earlier chapter of the present study and also in the companion volume. But it possibly requires a final brief mention here, in connection with competition and monopoly, because the popular notion is that a monopolist supplier can charge what he likes whereas a supplier subject to competition can only get such prices as the market will yield. The sum of the matter is something like this. For the various reasons given above, there is most often an element of benevolent monopoly about the character of port undertakings: if it were not so—that is, if competition between ports could always be relied upon to keep charges at reasonable levels—there would be no need for the legislature to fix maximum charging powers, as it so often done. But it *is* commonly done, and special authority to exceed statutory maxima is only obtainable from the responsible Minister and in exceptional circumstances, and therefore this factor alone is sufficient to pare down the theoretical monopoly to harmless proportions. In addition, there is some element of actual or potential competition always tending to check the monopoly, such as it is. For example, the industrial midlands of England can import and export, in theory, through the Mersey, the Humber, the Thames or the Bristol Channel. In fact, as has been said, many other factors operate to condition the choice — the availability or non-availability of suitable steamship services, the comparative efficiency and cheapness of inland transport services between the works and the port, the suitability of port installations for particular ships and particular cargoes, the existence of established markets in one place and not in another, and so forth. We may conclude, therefore, that port undertakings may be regarded broadly as being benevolent monopolies, operating for the public good, diluted considerably by healthy competition, an element of which, by generating a spirit of emulation, tends to produce efficient service and a progressive policy of port development. The matter could be stated equally reasonably in reverse—port undertakings are theoretically and basically competitive but, because of (1) their varying degrees of physical development, (2) the comparative rigidity of the great trans-ocean steamship routes, (3) the existence of established markets, (4) the influence of hinterlands, and (5) the existence of specialist port installations for specialist trades—the selling power of a few great ports tends towards group-monopoly over a large part of the field of seaborne commerce.

Co-ordination.

According to one reliable dictionary of the English speech, when we co-ordinate, we arrange in due and relative order with the object of producing harmony. Over the last 40 years, proposals have been made from time to time for doing something of this kind to the seaports of the United Kingdom. Manifestly, any such proposals must start from the proposition that the existing arrangements are not as good as they might be and must go on to show that certain alterations would make things better. The protagonists of change have asserted that Great Britain is over-dockised; that there is not enough total trade to keep all existing ports busy enough to be financially secure; that in some cases port undertakings compete unwisely against one another and so duplicate facilities and plant wastefully: and that the multiplicity of governing bodies sometimes functioning on one estuary or on a limited stretch of coast leads to overlapping and even confusion in administration and operation. The cure for these evils, the reformers have suggested, lies in the regional or estuarial grouping of all port undertakings around a selected few of the greatest ports in the Island. By such a re-arrangement, it has been urged, the machinery of administration could be simplified, centralised, improved and made less costly: wasteful overlapping and duplication would cease: obsolescing and decaying installations could be abandoned if their useful life was over: and the remaining healthy ports could take care of any additional traffic and make good use of any extra revenue thus accruing.

There has been no universal acceptance of the validity of these propositions but a good deal of thinking, discussing, writing, investigating and reporting has revolved around them. Two world conflicts have interrupted these activities, measures of temporary war-time regionalisation have been tried out, the Transport Act of 1947 has made its own partial impact on the matter, and the Transport Bill of 1952 also contains some relevant clauses.

Those who are as yet unconvinced by the arguments for grouping, base their doubts on a variety of considerations. They are apt to point out that by making a thing bigger you do not necessarily make it better—indeed (they say) you sometimes make it unwieldy, topheavy and slow in action. They urge that if an independent port arose out of the life of its neighbourhood, and if it is functioning usefully to-day—even though with an occasional struggle—then it may safely be left to continue its autonomous existence until the day comes —if ever—when it can function no longer. Again, they believe that the local people are the right people to administer the local port and they are apprehensive of remote control, and decisions made with imperfect local knowledge. They hold that as all schemes for port improvement, financing and borrowing are subject to authorisation or veto by the Minister of Transport and H.M. Treasury, there is no real danger of unwise expenditure and no occasion for more controls. They stress that the great need of the day is more trade in the ports and that the time is inappropriate for discussing new methods of port government. Finally, they maintain that the needs of shipowners and trades vary very considerably according to size of ship, type of trade and destination or origin of cargo, and that Britain requires all her existing ports and will be best served if they continue to function independently in a spirit of healthy rivalry.

As has been remarked, this particular argument did not begin yesterday and it may possibly continue for some time to come. In the meantime, the port undertakings may be relied upon to continue with their special duties in the vital task of national economic recovery.

Before and after the Transport Act, 1947.

At a time like the present (September, 1952), when Parliament is again turning its mind to the organisation of transport in Britain, it may be a help to students of port economics to recall the main course of events leading up to the present position so far as concerns docks and harbours. In earlier chapters, the general lines

Port Economics—continued

of port origins, development and organisation have been traced up to and through the 19th century. In our own century, the principal landmarks have been the war of 1914-18, the Royal Commission on Transport 1928-1931, the war of 1939-1945, the Transport Act 1947, and the Transport Bill 1952.

The war of 1914-1918 brought about a remarkable increase in the volume and efficiency of road transport and this affected rail transport, the coastwise sea route and—at one remove—the seaports of the United Kingdom. The effect upon railways and coastwise shipping was so fundamental that in 1928 a Royal Commission on Transport was appointed "to take into consideration the problems arising out of the growth of road traffic and, with a view to securing the employment of the available means of transport in Great Britain (including transport by sea coastwise and by ferries) to the greatest public advantage, to consider and report what measures, if any, should be adopted for their better regulation and control, and, so far as is desirable in the public interest, to promote their co-ordinated working and development."

The Royal Commission noted that about 50 U.K. harbours, great and small, were owned by railway companies and they were advised in evidence that such ownership was not in the public interest because (it was suggested) such harbours would be particularly planned for railway service and also the railway-dock-owners would tend to cut rates against independent harbours. On this question, the Commission concluded that in principle the best kind of authority to own docks and harbours is a public trust but that, in fact, there might be nothing gained by taking the existing railway ports out of the hands of the railway companies. The Commission also expressed the view that port trusts should not be confined to single ports but should control all the harbours in a particular district. The Dock and Harbour Authorities' Association, when asked, preferred not to express any sweeping opinion on the last point but remarked that the unification of many formerly existing interests first on the Mersey and later on the Thames had resulted advantageously.

In the course of the war years, 1939 to 1945, regional port directorates were established to co-ordinate the work of groups of port emergency committees and to assist the Minister of Transport to secure the most effective war-time effort from the nation's seaports. Efforts were also made to establish inter-port exchange of certain types of cargo-handling gear. Port emergency committees were equipped with considerable powers in regard to port operation but it was generally found, in practice, that the statutory port and dock authorities, proceeding along normal lines, could achieve satisfactory results.

Towards the end of the war, the Dock and Harbour Authorities' Association was invited by the Minister of Transport to record its views as to anything that might be done, after the war, towards improving U.K. port organisation. The Association's general view was that the principles of independence and autonomy exercised through public trusts in U.K. ports had been thoroughly tried, had served the nation well and had successfully survived the test of time: and that if, in the future, changes were considered to be desirable in any particular locality, they should be sought, as in the past, by the traditional method of private bill procedure in Parliament. Nevertheless (the Association suggested) if, at any time, H.M. Government decided to entrust the Minister of Transport with some general power of review, it would be well for him to be provided, for his assistance, with an advisory council of experienced port administrators. At about the same time, a proposal that the docks and harbours of Britain should be nationalised, emerged, from other quarters, as a politico-economic issue.

Shortly afterwards (July, 1945) there was a change of Government, a transport bill was deposited and it passed into law as the Transport Act, 1947. The declared aim of the Act was to provide, or secure or promote the provision of public inland transport and port facilities within Great Britain for passengers and goods with due regard to safety of operation. For these purposes, the Act set up six public authorities—one of them to be the chief authority, namely the British Transport Commission, with five assistant authorities (later made into six), called Executives, to be concerned, respectively, with railways, road freight transport, road passenger transport, docks and canals, London transport, and hotels. On the 1st January, 1948, the railways and their ancillaries, including about 50 port or dock undertakings, passed by operation of law into the ownership of the Commission. As to the main body of Britain's ports—owned and operated by public trusts, municipalities, companies or private persons—the Commission was empowered to keep them under review and, in appropriate cases, to propose schemes about them with a view to securing their efficient and economical development or management.

For operational purposes, the Commission first delegated the ex-railway ports to the Railway Executive and thereafter they were progressively transferred—with the exception of the packet ports—to the Docks and Inland Waterways Executive. The latter body subsequently made groups of some of the docks thus acquired—in South Wales, on the Humber, and at Hartlepool and Middlesbrough. As to the independent undertakings, the Commission entrusted its reviewing powers to the Docks Executive who visited a number of ports, and held a series of conferences with interested parties. Some re-arrangement schemes were drafted and a report was published. None of the schemes has been implemented.

In its report for the year 1951, published on the 9th July, 1952, the Commission gives valuable and interesting details relating to its 46 major docks and 395 docks craft. The gross receipts of the docks in 1951 were £14.87 millions against working expenses of £14.05 millions. This gives a favourable working result of £817,000 against an adverse figure of £50,000 in the year 1950—but before charging anything, in either year, for interest on capital or contributions to sinking funds. The value of fixed assets and goodwill is put at £70,394,923. The Commission reports that, in operating, they made £1,141,000 in north eastern, southern and south western docks, and lost £324,000 in the Scottish, north western, Humber, South Wales and other undertakings — thus making the figure of £817,000 on the right side before apportioning any share of central charges. Every dock undertaking did better than in the preceding year: there was a large increase in imports through the docks, and, in addition, a full year's benefit was obtained from the increases of charges authorised in 1950, and further benefit from the 10% increase authorised as from the 16th April, 1951. Inward cargo was up on 1950 by 4.4 millions of tons (largely oil and spirit) but outward shipments were down by 1.4 millions of tons. The coal shipment, considered alone, decreased by 2.8 millions of tons. The report laments that, at some of its docks, overseas traffic in coal has been virtually extinguished since pre-war days: and heavy deficits were incurred at certain fishing ports.

The Transport Bill, 1952.

In October, 1951, another change of Government occurred and, within recent weeks, a new measure dealing with transport has been drafted and deposited as a bill in Parliament. In its present form, it contains certain clauses relating to the ports, docks and harbours of Great Britain.

The following words occur in Section 2 of the Transport Act, 1947. "Subject to the provisions of this Act, the Commission shall have power . . . to provide within Great Britain, port facilities . . . " and, in Section 125 (1), port facilities are defined as "the constructing, improving, maintaining, regulating, managing, marking or lighting of a harbour or any part thereof, the berthing, towing, moving or dry-docking of a ship which is in, or is about to enter, or has recently left a harbour, the loading or unloading of goods, or embarking or disembarking of passengers in or from any such ship, the lighterage or the sorting, weighing, warehousing or handling of goods in a harbour."

The new Bill proposes to cancel this power except in any places where it was being exercised on the 1st July, 1952, or in places where, on that day, such power resided in the Commission under an authority other than section two of the Transport Act, 1947.

The new Bill also proposes to repeal sections 66 to 68 of the Transport Act—that is, to put an end to the Commission's powers to review trade harbours and to propose schemes about them. The student of port economics is recommended to study the text of the new Bill alongside Chapter 12 of the companion volume (Port Operation and Administration—Chapman and Hall).

(To be continued)

Survey of Poole Harbour

Changes in Channels and Banks during Recent Years

By F. H. W. GREEN (Commander R.N.V.R.) and J. D. OVINGTON (Nature Conservancy) and H. A. I. MADGWICK (University College, Southampton)

Introduction.

At the suggestion of the Poole Harbour Board, the University College, Southampton, was invited early in 1938 to undertake some research on changes in the channels and banks in the harbour. Since it was immediately appreciated that the unusual features of this South Coast inlet made it a very suitable place for scientific research, the results of which were likely to be of practical and general application in harbour conservation, the invitation was accepted. A summary of the work carried out in 1938-9 was published in 1940 (Green)* It was realised that there was a need for periodical surveys of this kind in order to understand the development and evolution of the harbour, and the present survey contributes to an understanding of the changes which have taken place in twelve years. The survey was concerned with the nature of the bottom and of the drying banks in that part of the harbour in which the greatest change was apparent.

Methods.

The positions shown in Fig. 1 at which samples were taken were fixed by simultaneous readings of two sextants on conspicuous objects on the shore, the locations of which are exactly marked. These positions in general were quite reliable since on all days except the last the weather was calm and visibility good so that each sextant reading was checked twice.

All samples except those situated above high water level were collected from either a motor boat or dinghy using a grab which under normal conditions brought up approximately 100 cc. of material. The grab was suspended by two ropes, one of which took the strain on the descent, and the other, after closing the jaws, took the weight on the upward haul. When insufficient material was brought up—usually because of fast-flowing tides in deep water — the operation was repeated until an adequate quantity was brought on board. Although weighted with lead the grab collected the surface samples only and never penetrated more than two inches into the bottom deposits.

The samples were stored in aluminium containers and dried at a uniform temperature of 60°C before laboratory analysis.

The particle size fractions of the samples were determined by washing 25 gm. of each sample with a litre of hot water through a nest of sieves having a diameter of 3.5-in. and arranged with progressively smaller apertures. The material on the sieves was rubbed as lightly as possible so as to ensure complete sieving and, when as much material as possible had passed through each sieve, the sieve was dried and the weight of material retained by the gauze was determined. The residue which passed through the last sieve was collected, evaporated off on a water bath, dried and weighed. The same range of sieve apertures, i.e. 0.10-in., 0.05-in., 0.025-in., 0.017-in., 0.01-in. and 0.005-in. as used previously by Green, were employed for comparative purposes. The material collected by the first sieve (aperture width 0.10-in.) consisted either of small stones or shells, which occurred somewhat haphazardly, and was ignored when the percentage proportions of the various grades were calculated.

The organic content was determined by measuring the loss in weight of approximately 15 gm. of sample after igniting in a muffle furnace maintained at a temperature of 700-800°C for about two hours and cooling in a dessicator.

Fig. 2 was constructed by plotting the distribution of the size groups containing the largest proportion of sieved material in each sample, i.e. the mode. This map is directly comparable with the map made in 1938, but a more detailed picture of the present distribution has been made by graphical determination of the median grain size for each sample and plotting the result (Fig. 3). The standard deviation (Fig. 4) is an index of the relative homogeneity of the different samples and a higher standard deviation indicates a sample with grains of mixed sizes whilst a low standard deviation indicates grains of fairly uniform size. There are inevitable shortcomings in such an index, the chief of which lies in the fact that in many samples the highest proportion of material fell into the smallest size group so that too much significance must not be attached to the correspondence between high standard deviation and the distribution of finer material. The organic content was represented by percentage loss on ignition of each sample and this is mapped in Fig. 5.

Results.

Within the area surveyed in detail, it was nearly always possible to collect a sample sufficient for laboratory analysis; only occasionally, when the tidal flow was great, was the amount brought up by the grab insufficient for this purpose, but it was adequate for visual description. The material lying on the harbour bottom showed considerable variation ranging from a coarse yellow sand to a black sandy silt. In general appearance most of the samples were uniform, but in a few instances there were recognisable thin layers of different texture and colour. Shell fragments were present in some areas. In the upper part of the harbour, the surface of the mud-

*Reviewed in the August 1940 issue of this Journal.

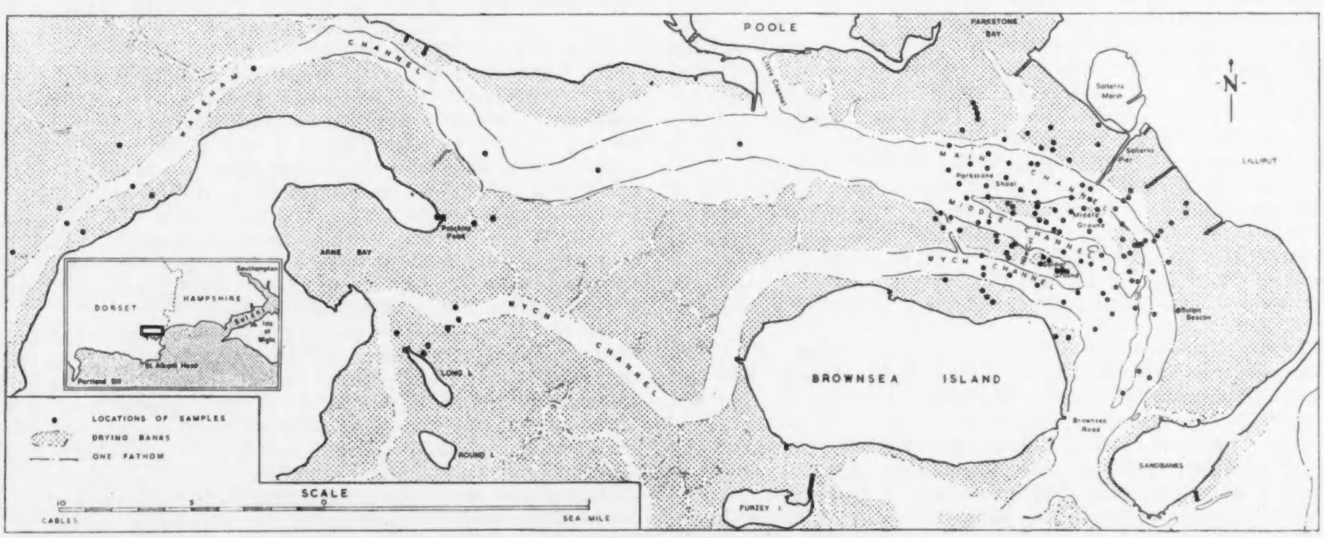

Fig. 1. Poole Harbour. The survey area.

Survey of Poole Harbour—continued

banks, on which *Spartina townsendii* is dominant (F. W. Oliver 1925), consists of a closely interwoven mass of rhizomes and roots between which the soil, mostly black mud, is trapped.

In general the bottom deposits of Poole Harbour are fine-textured, but there is an "embayment" of relatively coarse material extending northwards from Brownsea Roads across Middle Ground to Salterns Pier. The most marked changes in texture occur round the edges of this embayment. The maps of particle size distribution do not show an obvious correlation with the bottom topography and an illustration of this fact is furnished by comparing the following median particle sizes at three different levels on the edge of an underwater slope which was clearly visible from the boat:

Foot of slope	...	0.0055-in.
Centre of slope	...	0.0054-in.
At top of slope	...	0.0056-in.

It would appear that there is in this part of the harbour a correlation with tidal flow. Thus the embayment of coarser material corresponds with the stronger and most consistent flow of the flood tide and to a lesser extent of the ebb. (See pp. 26 and 27, Green 1940.) Further up the harbour there is in general a distinction between very fine material on the banks and shoals and somewhat less fine material in the channel.

The only sample of beach sand collected came from Patchins Point in the upper harbour. It was considerably coarser (Median 0.0159-in.) than anything found on the bottom.

The degree of homogeneity of particle size, as shown by the standard deviation, varies considerably within the area studied in detail. The greatest mixing of particles occurs within a broad band extending north-eastwards from the N.E. corner of Brownsea Island to beyond Main Channel. This band coincides with the area where both flood and ebb tides are subject to slowing up through changes in direction of the channels. The three local patches of higher standard deviation occur on shoals, and there is in fact a correspondence in general, though not in detail, between low standard deviation and depth of water. In the upper part of the harbour the material is generally well graded, especially in the channels. The sample of sand from above H.W.M. at Patchin's Point was poorly graded.

The organic content of the samples within the area surveyed in detail, ranged from less than 1 per cent. to about 20 per cent., though as much as 32.3 per cent. was recorded from mudbanks dominated by *Spartina townsendii* and *Glaux maritima* in the upper harbour. There is a general correlation between high organic content and areas uncovered at low water or otherwise of shallow depth. While on the marginal banks the percentage loss on ignition is never less than two and mainly over four, the high organic content on Middle Ground and Soldier Ground occurs only in patches separated by areas of under 2 per cent. On the marginal banks the highest organic content, over 8 per cent., is found adjacent to the channel edge. In the upper harbour the organic content increases gradually upstream but the contrast between channel and adjoining banks becomes less marked except where vegetation is growing.

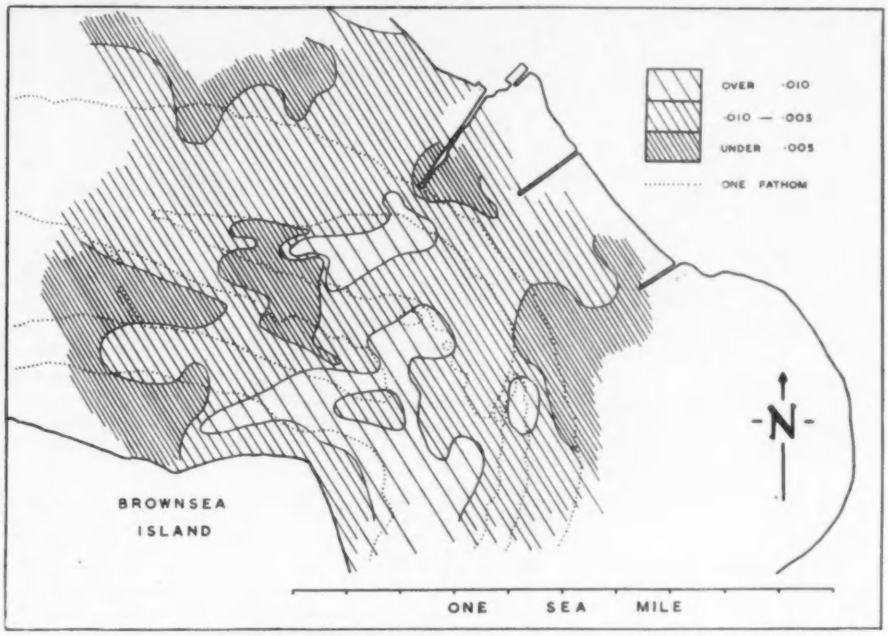

Fig. 2. Texture of bottom deposits as shown by the mode i.e the size grade (in inches) in which the largest percentage of the sample was placed.

Discussion.

The area between Brownsea Island on the one side and Salterns and Lilliput on the other, appears to be the area of greatest variation in bottom deposits and of more rapid change in underwater topography than most other parts of Poole Harbour. This band separates the upper part of the harbour, characterised by finer bottom deposit and higher organic content, from the lower part, floored by coarser material of lower organic content. Between these two parts of the harbour the tidal streams have to negotiate a right-angle turn, and the lines of equal standard deviation (i.e. of grading of particles) both in 1938 and 1951 show this sharp change in direction.

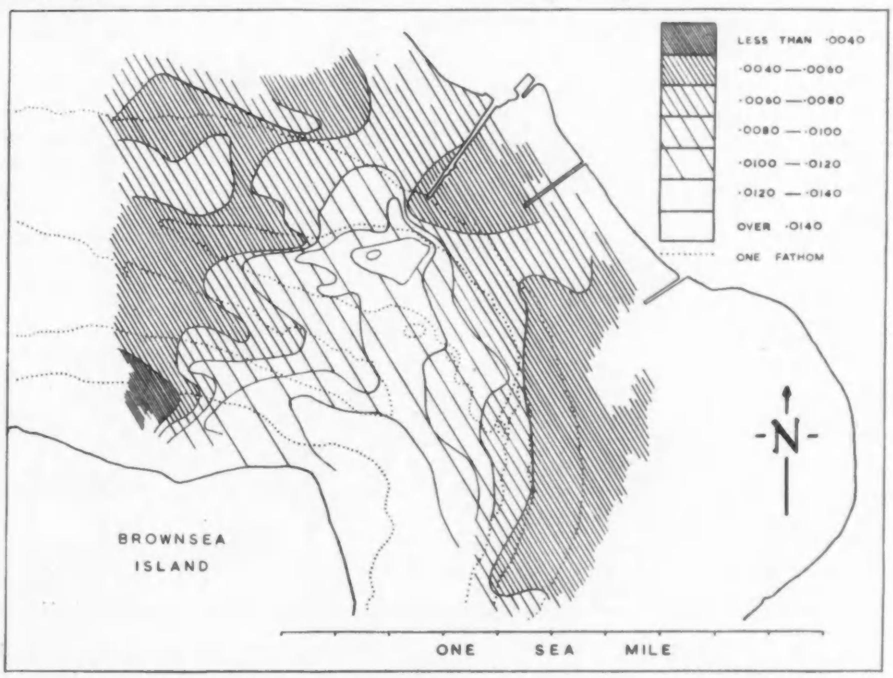

Fig. 3. Texture of bottom deposits as shown by the median grain size in inches.

Survey of Poole Harbour—*continued*

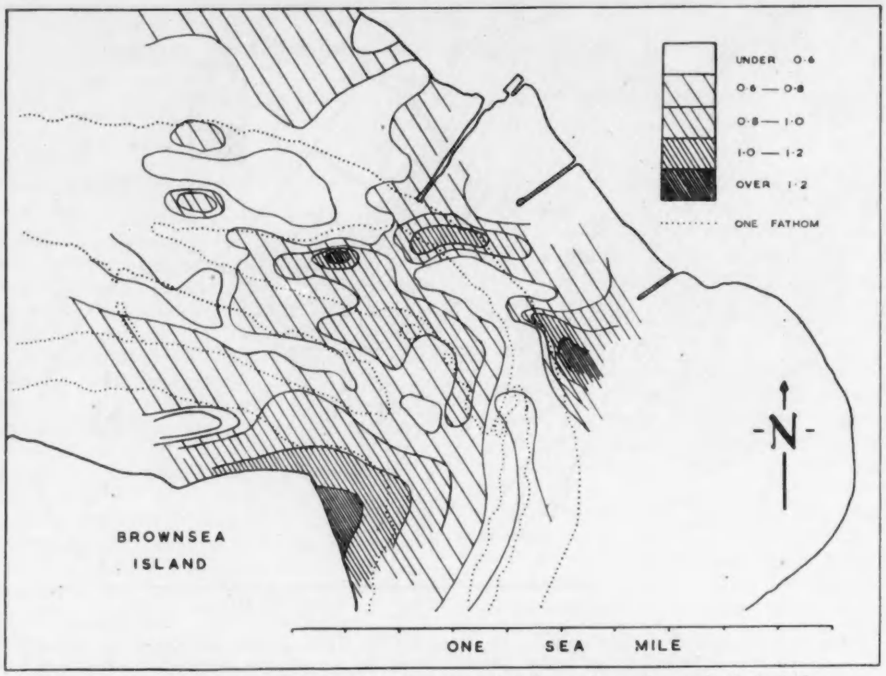

Fig. 4. Homogeneity of bottom deposits shown by lines of equal standard deviation.

Within this band one of the most striking features is the patchy distribution of high organic content along the banks of Middle Ground and Soldier Ground. These patches were probably continuous at one time, and it is indeed known that *Spartina* was growing on Soldier Ground as late as 1938, and their present distribution reflects the erosion which is still taking place of the material which had been previously built up. Ascending the steep eastern edge of Main Channel there is a rapid increase in organic content towards the outer edge of the marginal banks is a general feature it is noteworthy that in this particular case both the flood and ebb streams impinge here on the steeply sloping edge.

The greatest change in bottom topography since 1938 has been the increased depth of Middle Channel. Whereas a least depth of 1 fathom was recorded by the Admiralty in 1934, there is now no sounding of less than 2.1 fathoms. This deepening has largely taken place naturally, though some dredging has been carried out at the eastern end of Soldier Ground. During the same period depths in the Main Channel have in most places diminished, while slightly greater depths are now recorded over the central part of Middle Ground (in line with Salterns Pier) and over Parkstone Shoal. The New Cut, across Soldier Ground, is now deepening and widening actively, and the tip of Soldier Ground itself, though still a topographic feature has been worn off and now has greater depths over it.

The general range of particle size in 1938 and 1951 is comparable. The tongue or "embayment" of relatively coarse material, stretching northwards from Brownsea Roads, which was recorded in 1938, is shown again in 1951, but there appears to be no longer a branch extending into Main Channel. Samples taken in 1951 confirm the indications of the 1938 survey that fine material covers the bank east and north of Main Channel. Soldier Ground has lost much of the capping of fine material shown in 1938.

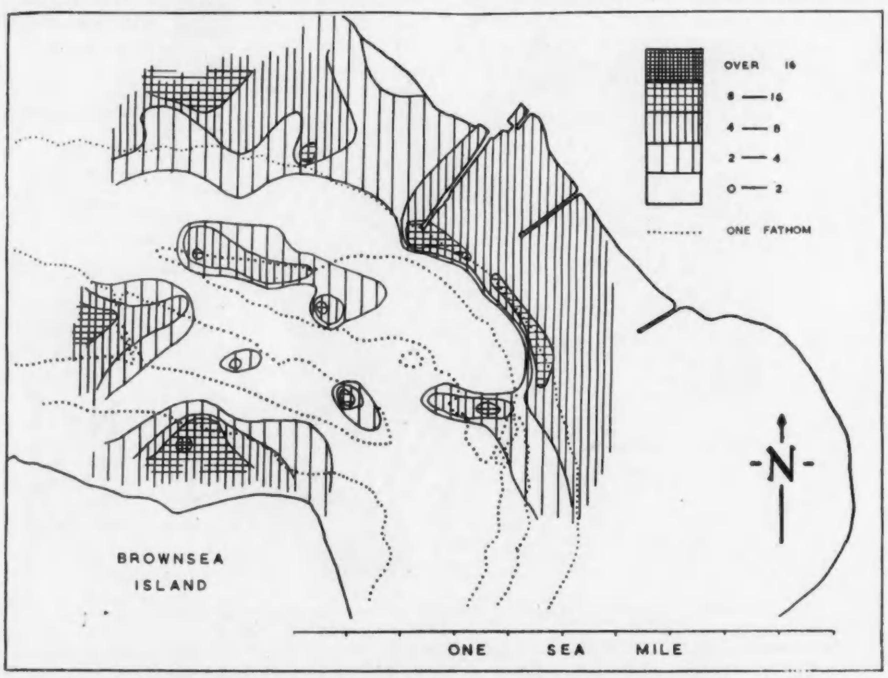

Fig. 5. Percentage loss on ignition i.e. index of organic content.

Acknowledgments.

Acknowledgment must be made for the invaluable assistance rendered by Captain C. H. Horn (Harbour Master) and Mr. A. F. Chapman (Harbour Engineer), including the services of boats and boatmen, and to Messrs. M. J. Bristow and J. B. Chaffey of University College, Southampton, and Miss V. Arrow of the Nature Conservancy, the remaining members of the team which carried out the survey. The charts were drawn by Miss N. Tweedie-Stodart.

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Port Elizabeth Facilities

New Berths to be Provided

According to reports in the South African press, sanction has been received from the South African Railways and Harbours Administration, for an immediate start on certain improvements at Port Elizabeth harbour. The work includes the lengthening of the tanker berth, so as to accommodate the longest tankers which the oil companies send to South Africa and the construction of a direct railway link between the Charl Malan and No. 2 Quays. Also the North Jetty is to be strengthened. Sanction is also expected to be received shortly for work to start on the south facing of No. 2 Quay. When completed the new facing will be known as No. 3 Quay and will give the harbour a further three shipping berths. Parliament has already voted a total of £1,563,600 for this work.

The Port of Stockholm

A Leading Harbour of the Baltic

By PAUL LEIMDORFER of the Stockholm Harbour Board.

(concluded from page 104)

THE PRESENT PORT

The Port of Stockholm has a water area of about 3,600 acres and it extends to about six miles from east to west (Fig. 2). The total quay length amounts to about 12 miles, disregarding about two miles of small landing piers and jetties specially designed for pleasure boats and skiffs. For loading and discharging there are the harbour cranes, trucks, tractors and mobile cranes already referred to. Most of the docks are connected with the State Railway system, and the length of railway tracks along the quays exceeds 40 miles. The floor space of warehouses and sheds amounts to 1,300,000 sq. ft. and comprises cold room storage facilities as well as freezing rooms.

The whole port can be divided into four main parts, viz.:

(1) The harbours in Värta Bay.
(2) The harbours on the Baltic side of the city.
(3) The harbours along the Hammarby Canal and adjoining waterways.
(4) The Mälar group of harbours.

In the following paragraphs the more important harbours will be described. (See Fig. 2.)

1. The Harbours in Värta Bay.

The Värta Harbour is the oldest harbour in Värta Bay, the first part of which was built in 1879-86. Since then the existing structures have been strengthened in connection with deepening of the harbour. This started in 1903 and went on in yearly rates of about 300-ft.—600-ft. of quayage. To-day this harbour represents the city's largest import harbour for bulky goods, e.g. coal (Fig. 18), coke, salt, fertilisers, food and timber. Exports from this harbour includes iron ore (Fig. 19), pulp, paper and sawn timber. The harbour owns 28 cranes with a lifting capacity up to 10 tons. The major part of the land area is leased to private firms for storage of staple goods. There is a land customs office; arriving ships, however, are cleared in by the maritime customs department. Total quayside of Värta Harbour amounts to 8.400-ft. with water depths from 16-ft. to 30-ft.

The City Gas Works Harbour was erected around the turn of the century and is administered by the Gas Works themselves. It is mainly intended for the reception of coal and shipment of by-products of gas manufacture.

The Oil Harbour consists of seven piers partly of timber and partly of concrete with a total quayage of 1,100-ft. and water depth of 32-ft. The erection of a new Oil Harbour is planned, and full details of this project will be given in a separate article which is now in course of preparation.

The Free Port. Merchants were interested, from early times, in establishing adequate facilities for the storage of their cargoes until occasion called for their distribution or transhipment. The Royal charter authorising the erection of Free Ports was issued in 1907. But it was not until 1917 that quay construction was started. Warehouse No. 1 was built in 1918-19 and in 1919, the Free Port was provisionally opened.

On January 1st, 1925, the Free Port Company, Ltd., was founded with most of its shares held by the city. The chairman of the Harbour Board is *ipso facto* a member of the directorate that comprises another six members, two of which are elected by the shareholders and the rest by the City Council, at least two of the latter are members of the Harbour Board. The directorate appoints a manager to the company.

On the basis of a special charter the company is empowered to handle cargo within its area. In fact, however, only loading and unloading of small vessels is undertaken by the company. It also supplies labour within the warehouses, sheds, etc., where this is not done by the stevedores.

The present Free Port covering a land area of 74 acres is mainly intended for trans-oceanic traffic. Apart from being a transit port, it serves the purpose of storing general cargo in its spacious warehouses for subsequent distribution, principally in the Greater Stockholm area.

The total length of quays in the Free Port amounts to 4,900-ft., situated on and close to a vast pier 550-ft. wide (Quays I-IV) and

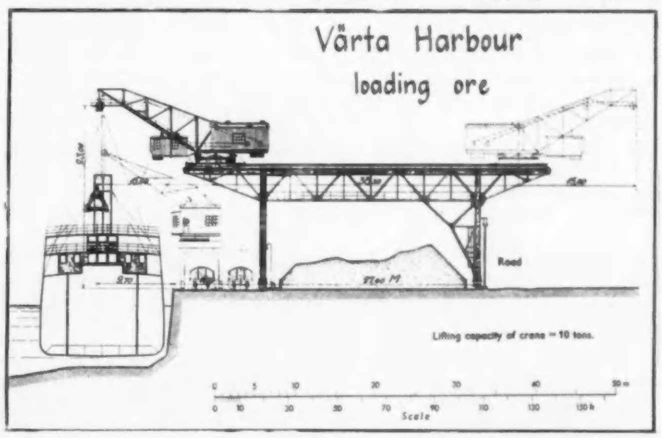
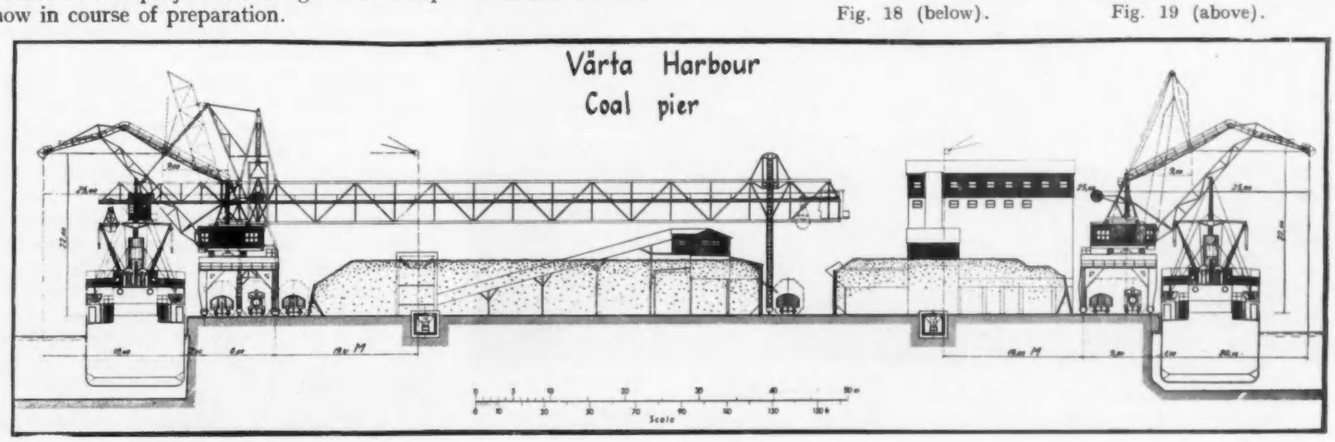


Fig. 18 (below). Fig. 19 (above).



Port of Stockholm—continued

at the southern side of the Free Port Basin (Quay V). The water depths of early quays were 26-ft.—28-ft. Between 1945 and 1950 about 550-ft. of new quays were constructed with a water depth of 32-ft. A water depth of 35-ft. for new quays of a length of 500-ft. is under consideration.

Most of the quays are served by three to six railway tracks connected with the State Railway system. The first harbour cranes were four gantry cranes installed in 1921. In 1926, followed eight double bridge cranes. Apart from a number of mobile cranes, trucks and tractors, there are, at present, 31 harbour cranes capable of lifting up to five tons. Another 14 large semi-portal bridge cranes of latest design will be delivered within the next few months, three of these new cranes will have a lifting capacity of 10 tons, the rest five tons.

There are four large warehouses. No. 1 was constructed in 1918-19 with two storeys and mezzanine. Total floor area 87,000 sq. ft. Live load on ground floor 1,000 lbs./sq. ft., on mezzanine 100 lbs./sq. ft., on first floor 360 lbs./sq. ft. Warehouse No. 2 and 3 were built in 1919-21 and 1924-26 respectively. Warehouse No. 2 is a four-storey building with a total floor area of 97,000 sq. ft., live load on ground floor 1,000 lbs./sq. ft., on first and second floors 360 lbs./sq. ft., on third floor 240 lbs./sq. ft. Warehouse No. 3 with a total floor area of 24,000 sq. ft. is designed for a live load of 600 lbs./sq. ft. on the ground floor and 300 lbs./sq. ft. elsewhere. The cellar floor of this warehouse contains chill rooms. Numbering of the warehouses refers to respective quays. Most of these warehouses are heated.

Finally, in 1931-33, warehouse No. 5 was erected with a total floor area of nearly 260,000 sq. ft. Live load 410 lbs./sq. ft. in bottom floor and 245 lbs./sq. ft. elsewhere. In 1946, this warehouse was enlarged by a fifth storey and by an additional five-storey wing of the most modern type. The total floor area of the new wing amounts to 70,000 sq. ft., of which about 4,500 sq. ft. are chill rooms with a temperature between 32° and 41° F., and 5,000 sq. ft. are cold rooms granting a temperature as low as 5° F. Live load amounts to 200 lbs./sq. ft. in the first floor and 250 lbs./sq, ft. elsewhere. Up-to-date heating is provided in this new wing, of course.

In addition to the above-mentioned warehouses there are twelve single-storey sheds with wooden skeleton, two of which were constructed in 1923, the rest being erected in subsequent years. Altogether they cover a floor area of 280,000 sq. ft. Thus the total floor area of warehouses and sheds in the Free Port amounts to about 950,000 sq. ft. The port administration and customs offices are situated in warehouse No. 3.

Besides the warehouses and sheds mentioned above there are in the Free Port grain silos with a total capacity of about 17,000 tons.

2. The Harbours on the Baltic Side of the City.

The Stadsgård and Mast Harbours form a continuous quay with a total length of 6,400-ft. and water depths from 13-ft. to 32-ft. The last section of about 1,630-ft. of length was completed at the end of 1950 and is a most modern quay with 32-ft. water depth.

This is the harbour par excellence for European cargo traffic and is provided with 42 harbour cranes with a lifting capacity of up to five tons. Twelve of these cranes have been delivered quite recently and are of the semi-portal level-luffing electrical type of high efficiency. In the Stadsgård Harbour there are four buildings for cargo prepared for customs examination and besides there are two sheds. They cover a floor area of 220,000 sq. ft. and include a customs office. In the Mast Harbour sheds are lacking, but erection has just been started.

Skeppsbro Harbour. Both passenger and general cargo traffic to and from Finland is concentrated here. This harbour (Fig. 20) is equipped with five gantry cranes lifting up to 7.5 tons. There are three single-storey sheds for the customs office, passengers and general cargo. All of them have been erected in 1939-40 with a floor area of 6,900 14,500 and 4,600 sq. ft. respectively. They have a steel frame and roof trusses as well as concrete panel walls. The total quayage amounts to 2,800-ft. with water depths of 9-ft. to 20-ft.

Blasieholm Harbour, Nybro Quay and Strandväg Harbour are intended principally for managing the passenger and cargo traffic within the Stockholm Archipelago, and to minor extent, cater for cargo services within Scandinavia.

3. The Hammarby Harbours.

These include among others the **Northern Hammarby Harbour.** Its eastern part, called the Barnäng Quay handles mainly general cargo, the middle part, called Blecktorn Quay chiefly stores bulk cargo, e.g. coal, coke, cement, iron, salt and foodstuffs, etc., whilst the western part handles firewood, bricks, tiles and other materials of the building industry. A double-storey building for goods storage, customs and administration is located on the eastern part.

Total quay length: 6,060-ft., water depth 12-ft. 6-in. to 21-ft. 4-in. There are 17 travelling harbour cranes with a lifting capacity of six tons and one fixed crane lifting up to 20 tons. There are two sheds for storage purposes. The total floor area of sheds, offices, etc., amounts to 26,000 sq. ft.

The Southern Hammarby Harbour covers a land area of nearly 175 acres. Along the quay there are the large warehouses of the leading industrial concerns belonging to the iron and steel trade, as well as automobile works.

The total quay length is 3,300-ft., the water depth 21-ft. 4-in. and 13-ft. 2-in. There are five gantry cranes with a lifting capacity up to five tons.

The Årstadal Harbour is in the continuation of the Hammarby Canal and is mainly intended for the purpose of import and storage of coal and coke.

The Liljeholm Harbour, near the aforesaid Årstadal Harbour, is used mainly by vessels importing goods of the iron industry, as well as machines.

4. The Mälar Group of Harbours.

These cater for internal passenger and cargo traffic mainly of a coastal character. The principal harbours are as follows: (a) the Riddarholm Harbour, where the Göta Canal boats are accommodated, (b) Northern Mälar Quay, (c) Southern Mälar Quay, (d) Hornsberg Quay, and (e) the Bällsta Quay.

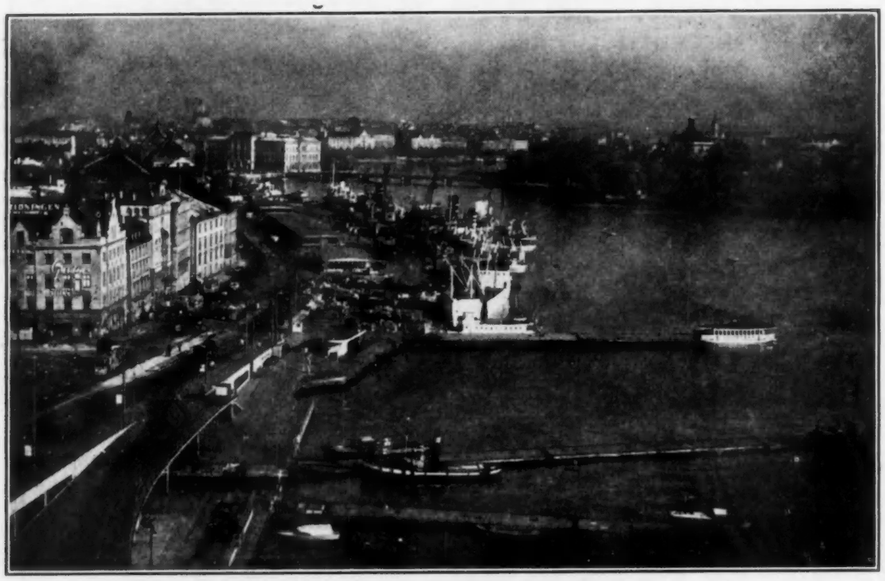


Fig. 20. General View of Skeppsbro Harbour.

Port of Stockholm—continued

Climatic Conditions.

Owing to the proximity of the Atlantic, Stockholm has rather a mild climate, considering its geographical position, as well as particularly favourable wind and weather conditions, as shown in Figs. 21, 22 and 23. It is evident that the climate in general, and the wind conditions in particular, are very favourable for the mooring of vessels, and also enable savings to be made in the costs of harbour construction.

In general, the approaches to Stockholm become frozen during January and are not free of ice until sometime in April. The City icebreakers, one of 4,000 h.p. and another of 1,200 h.p., maintain an ice-free channel the whole winter. There are no charges for ice-breaking within the port or in its approaches. The ice thickness is variable and amounts up to 15-in. A new combined ice-breaker and tug boat will be supplied within a few months.

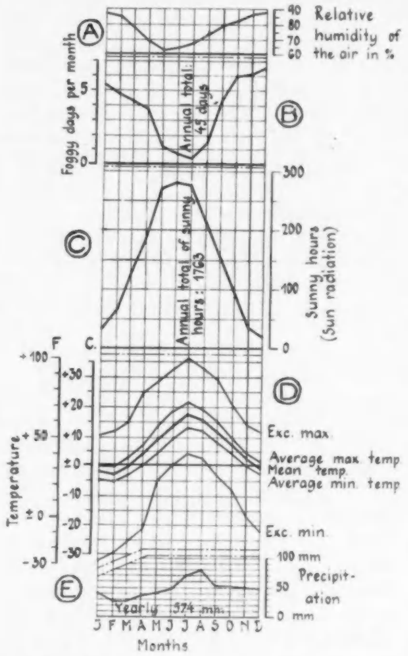
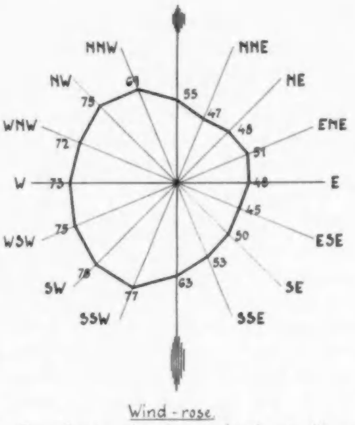
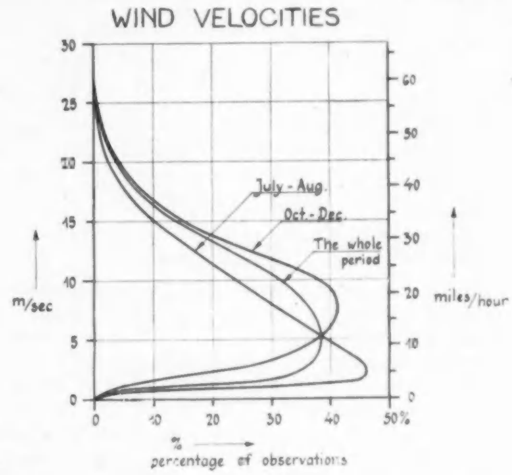


Fig. 21 (left).
Fig. 22 (centre).
Fig. 23 (right).



Wind-rose.
The figures give frequencies in promille of all observations. A period of $\frac{12}{1000}$ was dead calm



Pilot Service.

Government pilots are stationed at various places at the approaches to the Stockholm Archipelago; at Landsort, Huvudskär, Dalarö, Sandhamn, Furusund, Söderarm, Arholma and Södertälje. These pilots operate as far as the Stockholm port area boundary where the city pilots take over and conduct the vessels to the moorings allocated by the Harbour Master's office. The employment of the state pilot is obligatory, that of a city pilot is optional.

Towage.

Towage within the port area is undertaken by a fleet of tugs which, apart from two small boats, are privately owned. The organisations concerned are the "Transportbolaget" (Eng.- "Transport Company") who operate 13 boats of up to 800 h.p., and the "Söderström" Tug Company operating four boats of up to 750 h.p. The purchase of new and more powerful tug boats is included in the programme for the development of the port. In the beginning of 1953, a new tug boat with 1,020 h.p. will be delivered. It will be provided with radar, as well as fire-extinguishing equipment and a reinforced hull to enable ice-breaking.

Port Administration.

Apart from the Free Port whose organisation was dealt with previously, the rest of the port is administered by the Stockholm Harbour Board. It was established on January 1st, 1909, i.e. almost simultaneously with creation of the Port of London Authority, but 11 years before the Port of New York Authority was formed. The Stockholm Harbour Board is headed by a chairman elected by the City Board of Administration. The chairman is assisted by six members and six deputy members. One member and his deputy are appointed by the government, another and his deputy by the Stockholm Chamber of Commerce, the remainder are delegated by the City Council.

The General Manager is empowered by the Harbour Board to administer the port, which has five departments: (1) the construction department dealing with general planning, design, construction and maintenance of harbours, bridges, sheds and warehouses within the port area; (2) the mechanical department responsible for the cargo-handling machinery, the engines of the locks and movable bridges and electrical installations; (3) the Harbour Master's Office managing the port traffic; (4) the Accounting Office handling book-keeping and personal problems; and (5) the Cash Department having the care for collection of debts, harbour dues, payments, etc. Disregarding the stevedores, the number of employees of the Harbour Board amounts to about 1,000.

Stevedoring.

There are nine private stevedoring companies working in the port. The labour is employed on the basis of a collective contract between the stevedores' trade union and the stevedoring companies. The control of this agreement is executed by a special organisation, the Stockholm Dock Labour Board, which, moreover, manages the distribution of labour. The rates charged by the stevedoring companies for loading and unloading follow a regular tariff unless another rate has been specially agreed to in advance. The number of stevedores amounts to about 700.

Port Traffic.

Of the many standards by which the relative importance of a port may be assessed the levels of the import and export trades are the most convenient.

In early times the value of exports from Stockholm was approximately equal to the value of its imports. The port was then a natural outlet for pig iron and iron ore, which constituted 75% of the total exports of the whole country, and which came from the mining district of Bergslagen some 400 miles to the north-west. Gradually, however, more convenient ports were found for shipping these materials, such as Gothenburg, Gävle and Västerås, and in Stockholm iron was replaced by the less bulky but more valuable exports of the rapidly expanding engineering industry.

The following table gives data showing the changes in incoming and outgoing freight during the last three decades. A decrease in the volume of exports does not affect the value of the exports to the same extent, as the type of export comprises, in fact, mostly high-quality goods. A considerable reduction in exports, due to post-war economical stringency appears to have ceased, and an improvement in the balance of exports and imports seems probable. Another way of assessing the commerce handled by a port is to consider the shipping tonnage arriving, although this does not afford any absolute measure. The relevant data will be found in

Port of Stockholm—continued

Table 1. Showing Incoming and Outgoing Freight.

(1) The figures given in these columns are approximate, since goods leaving the port for an inland destination are not subject to dues, and thus not included in the relevant statistics.

Year	Incoming freight (tons x 1000) from places abroad	inland	Total	Outgoing freight (tons x 1000) to places abroad	inland (1)	Total (1)	Total of incoming and outgoing freight (tons x 1000) (1)	Ratio Exports / Imports	Outgoing freight / Incoming freight (1)	Vessels entering the port Number (x 1000)	Net tonnage (tons x 1000)
1922	1107	1163	2270	286	230	516	2786	0.26	0.23	33	2903
1929	1939	1861	3800	462	390	852	4652	0 24	0.22	53	5217
1930	1834	1912	3746	285	500	785	4531	0.16	0.21	54	5458
1937	2526	1435	3961	449	400	849	4810	0.18	0.21	43	5742
1938	2436	1718	4154	391	460	851	5005	0 16	0.21	44	6104
1939	2531	1798	4329	332	500	832	5161	0.13	0.19	44	5790
1946	1808	1713	3521	172	360	532	4053	0.10	0.15	26	4287
1947	2614	1484	4098	208	250	458	4556	0.08	0.11	24	4873
1948	2509	1483	3992	255	400	655	4647	0.10	0.16	23	4679
1949	2361	1493	3854	178	400	578	4432	0.08	0.15	24	4752
1950	2682	1689	4371	302	500	802	5173	0.11	0.18	25	5486
1951	3205	1695	4900	377	500	877	5777	0.12	0.18	23	5631

Table 2. Incoming and Outgoing Freight in the Ten Largest Swedish Ports during 1950.

Port	Incoming freight in million tons. FROM PLACES abroad	%	inland	total	Outgoing freight in million tons. TO PLACES (1) abroad	%	inland	total	Total of incoming and outgoing cargo in million tons. FROM AND TO PLACES (1) abroad	%	inland	(1) total	Total figures of 1937
Gothenburg													
Customs Port	2·96		0·90	3·86	1·19		0·70	1·89	4·15		1·60	5·75	
Free Port	0·25		—	0·25	0·51		—	0·51	0·76		—	0·76	
Total	3·21	20	0·90	4·11	1·70	12	0·70	2·40	4·91	16	1·60	6·51	6·00
Stockholm													
Customs Port	2·42		1·63	4·05	0·15		0·45	0·60	2·57		2·08	4·65	
Free Port	0·26		0·06	0·32	0·15		0·05	0·20	0·41		0·11	0·52	
Total	2·68	16	1·69	4·37	0·30	2	0·50	0·80	2·98	10	2·19	5·17	4·80
Malmö													
Customs Port	1·05		0·18	1·23	0·25		0·15	0·40	1·30		0·33	1·63	
Free Port	0·38		—	0·38	0·04		0·03	0·07	0·42		0·03	0·45	
Total	1·43	9	0·18	1·61	0·29	2	0·18	0·47	1·72	6	0·36	2·08	1·45
Gävle	0·79	5	0·90	1·69	0·80	6	0·04	0·84	1·59	5	0·15	1·74	1·73
Hälsingborg	0·72	4	0·06	0·78	0·47	3	0·05	0·52	1·19	4	0·12	1·31	0·68
Norrköping	0·70	4	0·27	0·97	0·27	2	0·06	0·33	0·97	3	0·33	1·30	0·91
Luleå	0·20	1	0·11	0·31	3·14	23	0·35	3·49	3·34	11	0·46	3·80	3·28
Oxelösund	0·26	2	0·02	0·28	1·51	11	—	1·51	1·77	6	0·02	1·79	2·41
Västerås	0·32	2	0·08	0·40	0·23	2	0·02	0·25	0·55	2	0·10	0·65	0·57
Trälleborg	0·35	2	0·02	0·37	0·08	1	0·06	0·14	0·43	2	0·12	0·55	0·46
	10·66	65			8·80	64			19·46	64			
Other Ports	5·74	35			5·00	36			10·74	36			
TOTAL for the whole country	16·40	100			13·80	100			30·20	100			

(1) Exports of iron ore—amounting to 7.3 million tons—through the Norwegian port Narvik are not included

the last column of Table 2, which shows that, last year, the port traffic reached a new maximum, but the peak shipping tonnage of the year 1938 has not yet been attained.

At present, the Port of Stockholm handles about 16 per cent. of the country's total import volume and two per cent. of its exports to and from foreign ports. The ten principal ports of the country handle nearly two-thirds of Sweden's total sea-borne exports and imports, which constitute almost the whole of the trade of the country, if the iron ore exports from the Norwegian port Narvik are excluded. The volume of iron ore exports through Narvik amounted in 1950 to as much as about 34% of the total exports.

With regard to Stockholm, as indicated in table 1, the ratio between the export and import volumes to and from foreign countries amounts at present to about 12%. When account is also taken of cargo shipped to and received from inland ports, the percentage rises to 18. Nevertheless, even considering the high class of goods that are being exported from Stockholm, the ratio between the value of exports and imports in 1950 did not exceed about 35%. The large difference between incoming and outgoing cargo represents a somewhat awkward problem, since it means that ships often have to leave Stockholm empty.

The Merchant Fleet.

The figures of the mercantile fleet of Stockholm since the turn of the century show a marked tendency to increase, which has particularly accentuated since World War II. In 1950, the tonnage reached that of the Gothenburg mercantile fleet, which had hitherto been the largest in Sweden. From a modest 11% of the country's total ship tonnage in 1900, the Stockholm fleet grew to the present figure of 35%. The distribution into the different classes of ships indicates that—though almost equal in number—the net tonnage of the motor vessels, which were introduced as late as 1913, make

Port of Stockholm—continued

up twice as much as the tonnage of steam ships. Sailing vessels—without and with auxiliary machines—which in 1870, constituted more than 90% of the whole fleet, and even at the turn of the century amounted to nearly 20% (when considering the number of vessels) have now become insignificant (see table 3).

FUTURE DEVELOPMENT

There are several aspects which may constitute the basis of discussion when planning a port's future improvements. All of them are subject to error and are to be used with precaution. In the following forecast it will be attempted to adopt the method utilising the relationship between the population figure and the port installations. From the data given on the traffic in the port, it is clear that the import figures have the greatest influence on the future development of the Port of Stockholm. When assuming that Greater Stockholm at the present time needs an annual volume of incoming freight of about five million tons, which has to be accommodated in ships using the port installations, and if the further assumption is made that the present length of about ten miles of mostly exploited quays is adequate, the average length of quay and the annual requirement of incoming goods per inhabitant are about 0.63-in. and five tons respectively. These figures enable elaborating a rough estimate of the necessary port improvements for the future.

Should the population of Greater Stockholm increase by, for example, 300,000 people during the next 20 years, as statistics suggest, an additional quayage of about 16,000-ft. will be required during this period. This probable requirement is causing serious concern to the city authorities, since suitable ground on which the port could be extended within the city boundaries—and preferably on the Baltic side—is very limited. About 2,500-ft. of space for new quays is still available in the Free Port, while in the Oil Harbour a proposed new pier will give approximately 1,200-ft. of new quayage. There is, in addition, a length of about 1,000-ft. available on the Hammarby Canal. To the west, on the shore of Lake Mälar it will be possible to construct a new harbour which will give an additional quay length of up to 10,000-ft. Its usefulness, however, cannot compete with that of the harbours on the Baltic side.

The most promising area for extension on the Baltic side is at Kaknäs, in the neighbourhood of the Oil Harbour in Värta Bay. Exploitation of this area is, however, not yet possible owing to a prohibitive agreement between the State government and the city. This area could provide a length of about 7,000-ft. of quays. At any rate, it is obvious that within a short time an extension of the port will have to take place on ground located outside the city limits, necessitating agreements with neighbouring towns.

Table 3. The Distribution of the Swedish Merchant Fleet with respect to the Home Ports.

Home port	Year	Steam- and motor vessels		Sailing vessels		Total		% of net tonnage of the total Swedish merchant fleet
		Number	Net tonnage (tons x 1000)	Number	Net tonnage (tons x 1000)	Number	Net tonnage (tons x 1000)	
Stockholm ...	1939	340	363	12	1	352	364	33
	1950	359	523	21	2	380	525	35
Gothenburg ...	1939	248	401	23	2	271	403	36
	1950	285	524	26	2	311	526	35
Hälsingborg ...	1939	85	103	14	1	99	104	9
	1950	69	112	6	1	75	113	8
Totals in the 3 above ports ...	1939	673	867	49	4	722	871	78
	1950	713	1159	53	5	766	1164	78
Other ports ...	1939	647	187	853	59	1500	245	22
	1950	809	273	623	44	1432	317	22
Totals of the Swedish merchant fleet ...	1939	1320	1054	922	63	2242	1117	100
	1950	1522	1432	679	49	2201	1481	
% of the total fleet	1950	69	97	31	3	100	100	

In respect of warehouse and shed accommodation the available space corresponds at present to about 1.3 sq. ft. per inhabitant, which is regarded as inadequate. Additional floor area is therefore required. In the Mast Harbour, a new shed with 25,000 sq. ft. of floor space is at present under construction and another of the same type will follow shortly. In addition, the erection of a building for customs, administration and storage is proposed, which will add a further 10,000 sq. ft. Other sheds and warehouses are also projected in the Mast Harbour with a total floor area of about 350,000 sq. ft. (see, for instance, Fig. 24) and in the Free Port with a floor area of nearly 450,000 sq. ft. (see Fig. 16). It seems probable that the above specified 860,000 sq. ft. of additional floor

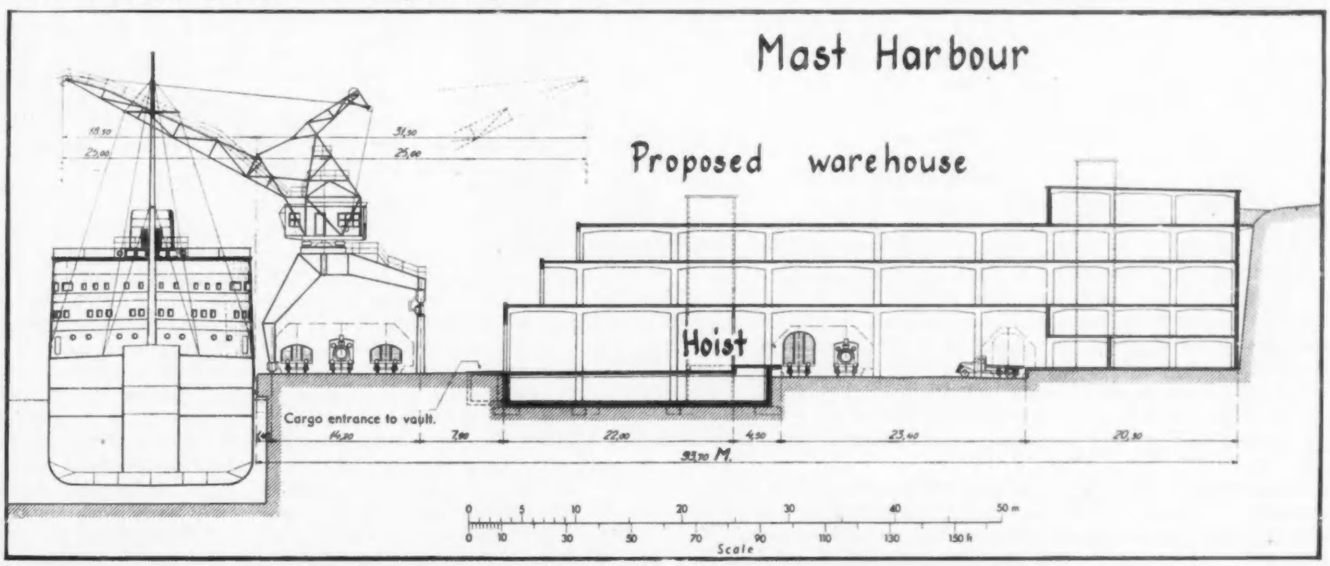


Fig. 24

Port of Stockholm—continued

area will satisfy the needs of the port during the next two decades.

In addition to the requirements for new quays and warehouses, it will be necessary to increase the facilities for handling freight, to enable full use to be made of existing installations. Account will also have to be taken of heavier demands on freight handling, resulting from a rise in the general standard of living. Amongst other improvements in crane facilities, the purchase is contemplated of a heavy duty floating crane with a capacity of 100—150 tons.

In order to encourage traffic to and from the Mälar Valley, proposals have been put forward to deepen the Södertälje Canal and the fairway in Lake Mälar (Fig. 1) to allow the passage of vessels with draughts of up to 24.5-ft.

Conclusion.

The Stockholm Harbour Board can review its 43 years administration with the satisfaction of having achieved much progress and it can face the problems of its fifth decade, whatever they may be, with confidence gained from previous successes.

The population of the Stockholm area is increasing constantly and thus there is a growing demand for food and other necessities of life. In recent times, there has been a considerable acceleration in the industrial development of Greater Stockholm and its surroundings. New factories are springing up with striking rapidity not only on the shores of the Lake Mälar, but also in its hinterland with its natural communications to the capital's port. The import of raw materials and the export of manufactured products is increasing and the quays of Stockholm are their natural inlet and outlet. Thanks to the enterprise of the Harbour Board, the port is well equipped for its task.

However, one cannot refrain from expressing regret at the difficulties arising from World War II which have prevented the Board from accomplishing all the larger works needed to further Stockholm's trade during the last decade.

It is to be hoped that these hindrances will disappear in the near future and thus allow the Board to proceed with its proposed developments for the benefit of the city and the whole country.

Acknowledgments.

This article is published with the authority of the Stockholm Harbour Board, and with the permission of Messrs. H. Linder and A. Wickert, the general manager and chief engineer respectively.

The author is indebted to Mr. H. Eneborg of the Royal Board of Trade, and Mr. W. Orre of the Stockholm Association of Shipping Lines for their kind assistance in obtaining and confirming some data given; finally, to Mr. T. Enekull, of the Stockholm Harbour Board, for reviewing the paper and making valuable suggestions.

Development of Malayan Ports

Recommendations of Committee of Enquiry

The Committee set up just over a year ago to investigate the future requirements of the ports of Malacca, Prai (Penang) and Port Swettenham and to consider what increase in port capacity is needed for the economic handling of the import and export trade of the Federation of Malaya presented its Report to the Federal Legislative Council recently.

Dealing with Malacca, the Committee stated that there are no valid grounds on which the Federation Government could bring official pressure on the Shipping Conferences to revise their decision against making Malacca a port of call for ocean-going ships operating on regular schedules. It found that a deep sea wharf would not be a practical economic proposition in the foreseeable future, but pointed out that there is need for an improved channel for lighters to provide access to godowns at all states of the tide. It also suggested that the possibilities of a coastal wharf should be investigated.

Port of Penang

The Committee recommended that Prai (Penang) should cater for a normal tonnage of 1½ million freight tons of general cargo a year, with peaks not exceeding 1¾ million and said that these tonnages could be handled without recourse to capital expenditure on deep sea berths until such time as the major portion of the present trade transfers from the Island to the mainland.

On the subject of additional deep water berths, the Report stated that though they would reduce operating costs they were not physically necessary at present and the savings on them would not justify giving priority to them. It also concluded that there was insufficient financial justification for the proposed remedial works at Prai. The position, it said, should be re-examined in 1957.

The Committee assumed that additional deep water wharfage, when needed would be on the mainland, but until a scheme for Prai South is examined, could not state whether it should be there or at Bagan Laur. It advised, nevertheless, that the Penang Harbour Board should construct additional storage accommodation and agreed that the Malayan Railway should go on extending storage accommodation at Prai.

It also considers that certain changes are necessary in the present organisation of the port of Penang if the long-term policy to which the rest of their report refers is to be soundly planned and efficiently carried out. Responsibility for the control, operation and development planning of the port of Penang as a whole is at present divided between the Penang Harbour Board, the Malayan Railway Board (in respect of Prai) and several private interests. This division of authority is not conducive to maximum efficiency and co-ordination of effort, and should be terminated so that both the day-to-day operation of the port and the detailed planning of future development may be made the responsibility of one Port Authority. The Port Authority should be brought under the effective ordinary jurisdiction of the Member for Railways and Ports as the member answerable for port matters in the Legislative Council.

The Committee have rejected the possibilities of all the port installations being brought under the control either of the Penang Harbour Board or of the Ports Department of the Malayan Railway. They therefore recommend the establishment in Penang of a new board, trust, authority or department, in the portfolio of the Member for Railways and Ports, to take over the entire responsibilities of the present Penang Harbour Board, the railway port installations at Prai and (in negotiation with the Settlement authorities) the management of Weld Quay. The new organisation, while subject to "ministerial" control, would be equipped with full executive and accounting responsibility, and would be headed by an officer of first class experience and record. Meantime the Committee recommend that present proposals to construct additional lighterage points on the mainland should be deferred for the consideration of the new authority. They recommend the establishment of a representative port board, analogous to the present Railway Board, to advise the head of the new Penang port authority. They emphasise that full co-ordination of operations between the railway authorities and the new organisation in all matters affecting railway access and operations. is essential, to ensure the proper development and efficient use of railway facilities.

Port Swettenham

"Dead weight tons" are the units by which Port Swettenham records its handling—as against Penang's "freight tons"—and the Committee recommended that it should adopt the figure of 750,000 tons of deep sea import and export cargo capacity (exclusive of petroleum products passing over a private wharf) as the normal working figure for planning capacity. A capacity of 1,000,000 dead-weight tons a year at peak periods should be available.

To cope with this cargo, three more deepwater berths are required and the Committee recommended that they should be constructed at the North Klang Straits site where the "operation of a new wharf is a practical and economic proposition and where almost indefinite expansion is possible." It envisaged tenders being called for this work in the middle of 1953 and a start made in 1954. It further recommended that $26 million should be earmarked from Federal or other loan funds and that in the meantime $1 million should be provided for preliminary work.

Erosion and Corrosion on Marine Structures

Practical Observations and Remedies*

By H. J. SCHAUFELE
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Introduction

The sole purpose of this paper is to present to the public more than 20 years' experience acquired in designing for, and eventually combating, the unusual forces of nature acting on marine structures in exposed waters. The structural design will naturally be determined by the use the project is called upon to serve and the standards of the designer. This particular phase of the overall picture, with the aid of available meteorological and oceanographical data for a specific area offers no particular difficulty in structural design.

The subject matter presented herein refers to observations made among the various pier and oilwell foundations constructed in the Elwood Field, California, during the interval between 1929 and 1935, and major maintenance problems to date.

Where protective measures made at the time of installation are explained, they refer to our own specific works, while the general observations in the field are confined to no one particular structure or type of design.

Location

For several miles in the Elwood area, the coast line is marked by a very steep shale escarpment, 30-ft. to 90-ft. high, rising from the beach. At intervals this escarpment has been eroded by streams from the mountains which have cut canyons that are persistent well out to sea, although filled with sand and silt to the level of the present ocean floor. These former canyons, as far as we have tested with jets, indicate depths up to 90-ft. from the ocean floor down to original shale.

The beach line, extending seaward, is a relatively smooth shale surface, dropping seaward about 40-ft. in depth to 2,500-ft. From the base of the escarpment this beach is intermittently covered with a mantel of sand varying in thickness up to 8-ft. from season to season. Beyond the breaker line to approximately a depth of 60-ft., there are extensive beds of kelp.

Design

On the first 1,650-ft. seaward of the pier, a three-pile bent of 8-in. x 8-in. — 32 lb. "H" section was used. Previous to driving, the piles were wire brushed to remove mill scale, washed to remove dust and loosened scale, and given two coats of asphalt chromate emulsion, having a minimum one-sixteenth of an inch of coating.

The first 13 bents seaward, or those in the normal breaker line, were protected by driving a 14-in. diameter $\frac{3}{16}$-in thick 8-ft. long steel cylinder over the pile through the sand into the shale, jetting the interstitial space clean of sand and filling the same with a 1 : 2 cement grout.

The reasoning behind this deviation from standard practice in the field was the experience of the designer, who had seen steel piles of structural shape cut off in the breaker line by abrasion of sand in suspension, whereas round shapes survived, such as the old Olympic Club pier on the San Francisco beach.

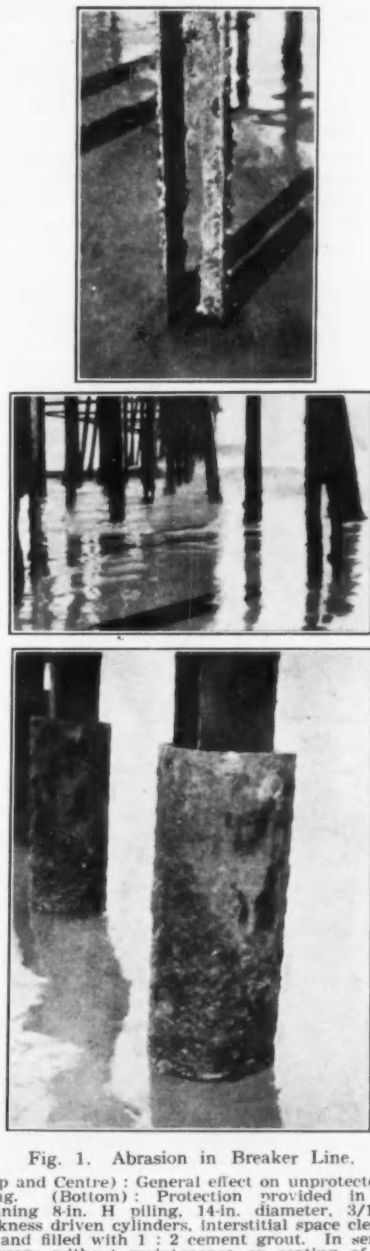

Fig. 1. Abrasion in Breaker Line.

(Top and Centre): General effect on unprotected H piling. (Bottom): Protection provided in the planning 8-in. H piling, 14-in. diameter, 3/16-in. thickness driven cylinders, interstitial space cleaned out and filled with 1 : 2 cement grout. In service 21 years without maintenance or coating of any type.

This detail of design proved to be very effective as the adjacent piers have had to have piling in the breaker range replaced or protected within five years after installation.

On one pier we acquired by purchase, the "H" sections in the breaker area, at the first sign of scouring, were protected by boxing the exterior of the pile with creosoted 2-in. thick planks, securing same with $\frac{1}{2}$-in. x 2-in. galvanised bands top and bottom. Incidentally, after fifteen years, the wood is intact but the top bands are cut through. Reference to illustrations will show the wisdom of this choice on new work and the boxing of piles already driven (Figs. 1 and 2).

The two basic divisions of the structures, as constructed, were the well or derrick foundations, and the working area or pier approach.

The various interests through their respective engineering departments set varying load conditions and it is worthy of note that there has been no failure through loading up to now on any of the structures—21 years in service—that were originally designed for a 15-year life, notwithstanding the fact that to-day's transportation and drilling equipment is 25 to 50 per cent. heavier than that of 20 years ago.

Choice of Materials

Inasmuch as the ocean bottom is shale, wood piling was out—except in a few cases where piers traversed aforementioned silt-filled shale depressions on the ocean bottom.

Little was actually known about the effect of pile cross-section pattern on the drag coefficient in 1929. Steel piling seemed to be the only solution, and because of the immediate availability and economics, structural sections were used. Our experience to date indicates the choice of steel was right, but the cross-section or pattern of the pile was wrong. The superstructure, consisting of caps, joists, and deck, was built of untreated structural grade Oregon pine.

Progressively, the next item we considered was the location of the welded transverse and longitudinal angle bracing. When you consider the long unsupported length of the piles or the high slenderness ratio, it is apparent that bracing of some kind is required. It is impractical to do this below the water line and too close to sea level. The braces gather floating kelp and debris. This becomes a hazard because of the additional weight, and especially because of the increased area exposed to wave action. Hence, by observation of an existing pier in the area, we decided our first bracing should be 8-ft. above the high tide line. We have never lost a rod or brace in 20 years and have never had to remove kelp suspended from the bracing.

We next chose the most suitable deck elevation above mean high water. Precedent indicated 20-ft.; however, we added 2-ft. to this and used 22-ft. as our deck elevation. The reasoning we used was based on obser-

*Excerpts from paper presented at First Annual Conference of Coastal Engineering held at Long Beach, California, 1950. Reproduced by kind permission.

Erosion and Corrosion on Marine Structures—continued

Fig. 2. Abrasion in Breaker Line.

(Top): Protection provided after construction 10-in. H piling, 2-in. x 12-in. creosoted boxing secured in position by ½-in. x 2-in. galvanised clamps. In service 16 years. Condition: timber, good; clamps, cut through at corners. (Centre): Attempts to protect after construction. Same as cut A except untreated timber. (Bottom): Attempt to protect after construction. Spiral-wrapped reinforced concrete. Failed when sheet iron form failed. Steel protected, however. Limited to tidal range.

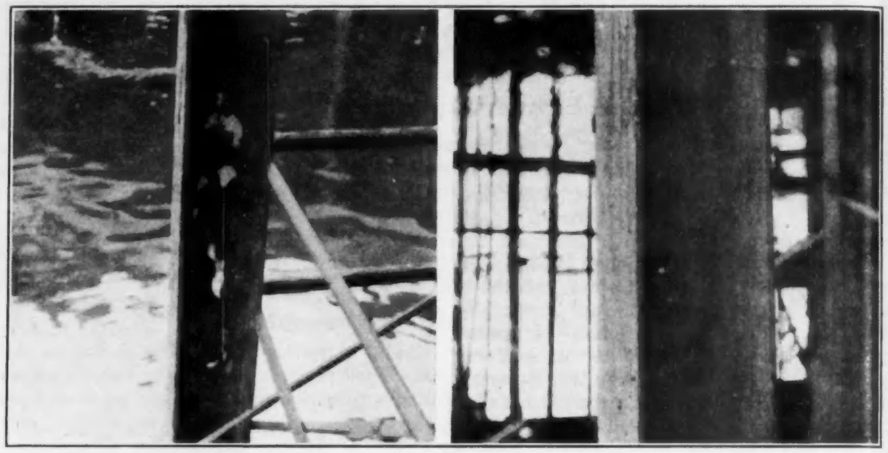

Fig. 3. Atmospheric Corrosion.

(Left): Very severe case of oxidation in atmosphere above tide range. 10-in. H pile, 0.564-in. web thickness; no protective coating. In service 16 years. (Right): 8-in. H pile, 0.300-in. web thickness, coated with 1/16-in. of asphalt chromate emulsion. In service 21 years. Never retouched.

vation that waves build up just before breaking. So far we have had no trouble from waves lifting the bottom of our deck system; however, a few high waves have reached the under side of the superstructure on other piers in the vicinity.

In 1935, six years after the construction of the original 1,650-ft. pier, it was deemed advisable to add approximately 800-ft. to the original pier to provide drill sites as close as possible to the axis of the anticline (or top of oil structure). The reason for bringing this information into the paper is to present the variation in design employed and results obtained therefrom.

On advice of the consultant, protection (coating) on piling was deemed of little value and he recommended the price of coating had better be spent in providing thicker steel. Hence, in this section of pier a four-pile bent of 10-in. x 10-in. — 54 lb. "H" Section, with no coating of any kind was used. Now, bear in mind the original pier built in 1929 consisted of a three-pile bent of 8-in. x 8-in. — 32 lb. piles coated, while this new section built in 1935 consisted of four 10-in. x 10-in. — 54 lb. piles uncoated. The bracing and superstructure are similar.

The wisdom in coating the piling as a protection against oxidation above the tide range is again illustrated by the pictures (Fig. 3). All hardware throughout, such as nails, drifts, bolts, nuts and rods were hot-dipped galvanised. The concrete mix for well foundations such as derrick legs, cellars and scupper decks was scientifically worked out. San Gabriel sand and gravel were used and the mix called for seven sacks of high silica cement per cubic yard with a maximum slump of 6-in. The concrete work was coated with bitumastic immediately after removing the forms.

In resume, the only protective measures taken during construction were coating the piling, jacketing the piling in the breaker line, ventilating all lumber to the fullest, creosoting all lumber bearings and laps, using galvanised hardware throughout and coating all freshly stripped concrete. It is worthy of note here that after 21 years' exposure, the piers are in continuous service to-day with a minimum of replacement and maintenance.

Regular visual inspections of exposed works above the sea level are made by coring lumber and calipering steel. Periodic sub-surface inspections are made by divers, again calipering the steel after removal of the organic growth. The Signal Oil and Gas Company have taken the caliper readings as furnished by the diver and recalculated areas and section moduli and from this data we are able to have a close check on our original premises of design.

Twenty-one years of observation on all piers in the vicinity has brought forth the following recommendations:

Piling, breaker line or sand bottom area. All piling should be cylindrical or circular in cross section to provide as near as possible a streamline flow past the pile for any direction of wave impingement. An auxilary sleeve over the pile of sufficient length to cover same between the limits of sand depth, is desirable. This choice of section provides an equal section modulus for any axis; also, if paints, wrappings, etc., are used, the circular cross-section provides less comparable surface area to cover and no angles, corners or sharp edges where it is difficult to build up coatings.

Piling should be spaced a minimum of five diameters for a dampening of eddies set up by adjacent piling. The piling should be filled with concrete for additional strength and stiffness to resist any distortion, or the pile should be sealed off or neutralising agent should be added to prevent interior corrosion. Structural sections in the breaker range can be protected by boxing, preferably with creosoted plank secured with heavy metal straps.

Coatings above the low tide range, certainly in our case, have proved to be better than the additional uncoated steel.

The above recommendations are based on the following observations:

(Breaker line). In about three years, noticeable wear and sharpening of flanges was noted where structural shapes were used. In five years the cross-section was considerably reduced and lenticular holes appeared in the webs.

("H" pilings). Those oriented so the web was normal to the wave direction were

Erosion and Corrosion on Marine Structures—continued

especially susceptible to abrasion. Many piers have had their piling replaced or reinforced in the breaker line within five years.

The condition of the piling given a protective coating 20 years ago is a convincing argument in favour of a protective coating at least for oxidation in the zone above the water line.

(Deep water piling inspection). Cleaning a selected number of piling from the underside of the cap to the ocean floor and observing and calipering same disclosed the following, proceeding up the pile :

No sand cut or abrasion was noticeable.

At approximately 2-ft. above the bottom, a highly anodic area was found with a noticeable loss of section. This may be related to the point of flexure; however, the environment is highly anaerobic, common to harbours and areas of decaying kelp. We corrected this by having a diver add metal sleeves to the piling and subsequent inspections have shown this has corrected the condition. The metal loss, whether it be chemical or electrolytic, is now from the auxilary metal jacket rather than the pile and we believe that no further loss of metal will take place at this critical point.

When you consider that on an average of six sec. wave periods in the space of one year you have 5,350,000 reversals of stress, multiplied by 20 years, flexure might well be responsible for at least a part of the condition explained above (Fig. 4).

Proceeding up the pile, anodic pits were found at various points. They followed no specific pattern or location and while not deemed hazardous, locations and lead impressions were carefully made for future comparison.

Our next perceptible loss of section on uncoated piling was above the water in the vicinity of the horizontal bracing welded to the piling. The loss of pile cross-section can be seen by eye on removal of the laminations of rust. The flange thickness is reduced to about 60 per cent. of its original thickness and, strangely, in a few cases, the webs are badly corroded. This condition does not exist to such a marked degree, if at all, where the piling and joints were coated 20 years ago. This again is a point of restraint and flexure. The only cure so far is removal of the section and welding in a " dutchman."

The writer recently attended the annual Sea Horse Convention at Kure Beach, North Carolina, where salt water corrosion was the sole topic. The general observation brought forth paralleled what we have here on the West Coast, with recommendations for prolonging the life of steel piling similar to those we are taking or have taken.

From the study of the subject discussed at the convention, it certainly convinces one that each environment has its own specific problems.

As of this instant, we are testing various types of pile protection such as paints, somastic coating, metal spray, galvanising and also cathodic protection, which seems to offer a solution at least to our underwater problems.

Bracing. Bracing should be of a minimum, located above normal wave heights and in areas where kelp is prevalent, consideration should be given to kelp loading. The section, where possible, should be round to reduce the drag coefficient of waves and the ease of re-coating. The principal objection to round section is fabrication.

Timber. The subject of wood preservation is a science by itself and all I can relate here are the precautions taken on our works to try to insure our superstructure and the results obtained. Again, the choice of untreated timber over treated lumber, even for 15 years, is a matter of environment. All lumber was rough structural grade. All bearings were mopped with hot creosote. All laps were mopped with hot creosote. All lumber was spaced or gauged insofar as possible to provide free air circulation. Deck planks were gauged $\frac{3}{4}$-in. All nails, drifts, bolts, etc., were galvanised.

After 20 years, aside from a few planks, the original deck and the original joists remain; some few caps, possibly 16 per cent., have been reinforced due to heart rot from water entry through checks.

By all means, provide as much air circulation as possible; keep the top surfaces of caps cleaned of all earth or wood fibre that might sift through the deck spacing and form a damp mat and induce decay from the top. When fungi or dry rot have taken over and auxiliary members are required, remove the ailing timber. The presence of such timber is a source of fungi spore and it is no longer a structural component of the work.

Concrete. Concrete offers the same picture as anywhere else along the Southern California coast. It " grows," whether reinforced or mass concrete. We have had success with high-silica cements and a scientifically graded aggregate for density, stripping and coating as soon as possible to exclude moisture. This also has protected ordinary Portland cement concrete.

There are instances along the coast where concrete cylinders 13-ft. in diameter have increased their diameter approximately 6-in. and have grown approximately 4-in. in height. Other cases have occurred in which cylinders of $\frac{1}{4}$-in. plate and 6-ft. diameter, filled with concrete, have either ruptured the weld or the steel failed.

Reference to accompanying photographs should emphasise the necessity of investi-

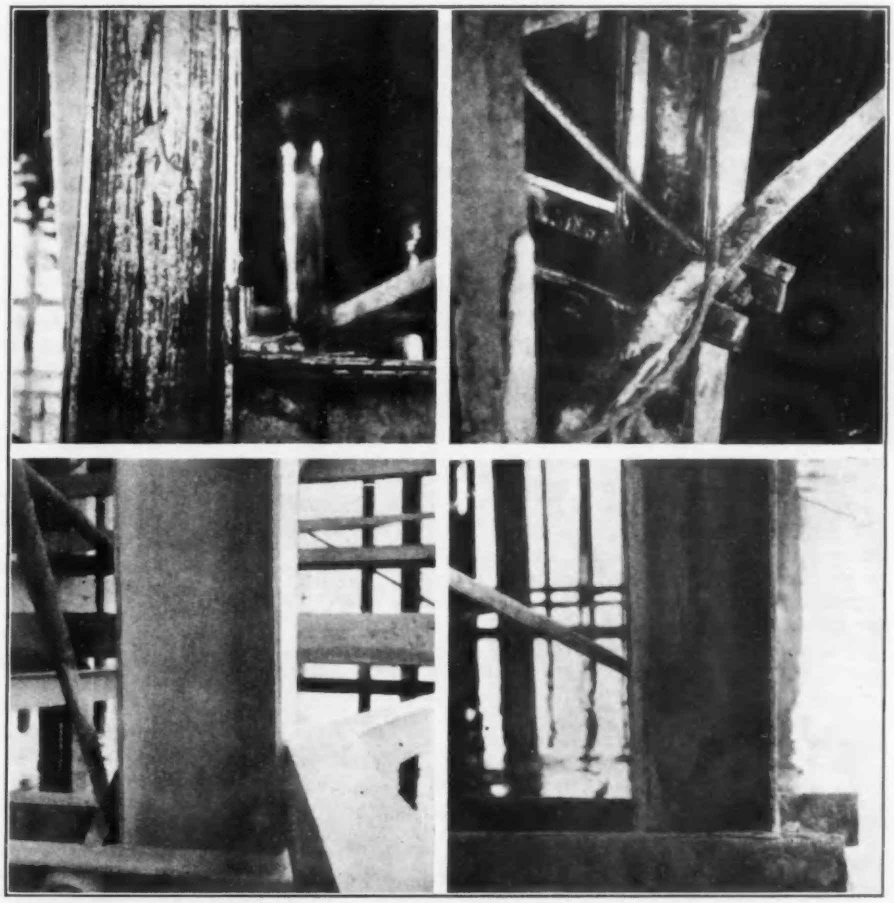

Fig. 4. Stress Corrosion.

(Top Left and Right): Typical corrosion in vicinity of restraint showing laminations of rust. In service 16 years. No coating protection. (Bottom Left): Typical corrosion in vicinity of restraint with rust removed. Note loss of section on the flange. In service 16 years. (Bottom Right): Note absence of above conditions where steel was coated with asphalt chromate emulsion. In service 21 years.

Erosion and Corrosion on Marine Structures—continued

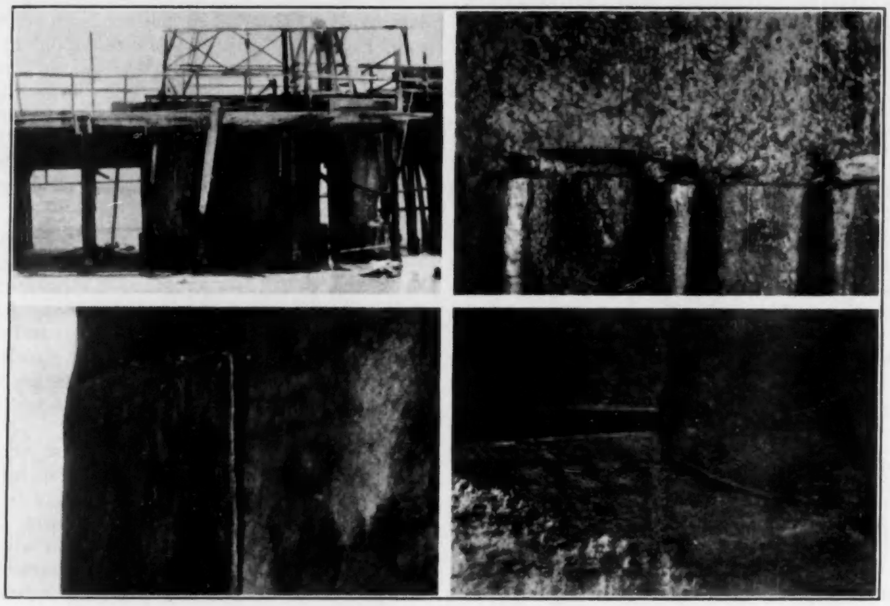

Fig. 5. Concrete in Salt Water Environment.
(Top Left): Mass concrete in wave area. (Top Right): Vertical rise from sheet pile forms. (Bottom Left): Mass concrete in ¼-in. steel shell above high tide line. Note weld failures. (Bottom Right): Mass concrete in ¼-in. steel shell above high tide line. Note shell failure.

gation of the chemical reaction between cements and aggregate in a damp environment (Fig. 5).

In summation, there is no panacea for the caprices of nature in its never-ending task of destruction and building. The insatiable appetite of nature must have sustenance, preferably coatings and/or anodes rather than structural members.

In designing, the economic comparison between long life with costly preparation to receive and ultimate application of coatings, must be made with shorter life using more frequent applications of a less expensive coating. In fact, in the original design provision might well be made for the ease of ultimate replacement of certain structural members.

The recent convention at Kure Beach, North Carolina, more than ever convinced the writer that each installation is a separate problem. Figures on the average i.p.y. (inches per year) losses by oxidation, abrasion, etc., of timber, steel, galvanising, etc., certainly were not applicable to Elwood structures. To keep various construction members—timber, piling, etc.—in balance, it is necessary to inspect, repair or replace at regular intervals.

In a study of this report and accompanying pictures (Figs. 1—5), the reader should bear in mind that many of the illustrations are of structures before replacement of members and others are of structures already razed or in the process of being razed. Where structures are in service, every possible known means of maintenance is being used to preserve them.

Correspondence

To the Editor of *The Dock and Harbour Authority*.

Dear Sir,

Handling of Cargo at European and U.S.A. Ports

May I ask you to give space in your periodical to some comments on the interesting and valuable paper on freight handling by Dr. Neumann of Hamburg, which was published in your issues for June and July last. The general conclusion that it is the quayside crane that is the most appropriate in European ports is, in my opinion, an over simplification of the problem and I will try succinctly to present some reasons for my point of view.

Before the First World War, practically all of the American ports were constructed and managed by the big railroad companies and the principles of private trade economy governed this development. During the last three decades, however, public influence on the construction of ports has increased, while the exploitation and equipment of port facilities were, and still are, mostly entrusted to private business. In Europe, on the other hand, we have followed a development of a contrary sense, i.e. the waterborne commerce has been the primary factor for many centuries, the railway traffic being a comparatively new transport facility. However, the European ports, in general, were, and are, owned and operated by state or municipal authorities.

Disregarding the considerable difficulties of introducing a new type of equipment in an old part of a harbour, it seems to me to be likely that it was a certain amount of slowness and inertness, characteristic of any public-managed undertaking, which postponed dealing with new systems of cargo handling.

The almost immaterial part that inland navigation is playing in America strongly contrasts with the traditions of Central and Western Europe where river transport was of importance at a time when America was not yet discovered. Nevertheless, there are several countries in Europe where the situation is more or less analogous to that in the U.S.A., e.g. Sweden, Norway, Finland and also some important areas in Eastern Europe. The comparatively few and distantly situated centres of the American continent where the major part of the population is accumulated, contrast with the location of the towns in densely populated Central and Western Europe. However, there is Scandinavia again, besides Russia, Poland and vast areas south of the Mediterranean, whose density of population almost corresponds to the U.S.A. figure (e.g. the distance between Stockholm and Kiruna in Northern Sweden is almost equal to that between New York and Chicago).

The negligible tide ranges along the American coast contrast indeed with the considerable changes of water levels in many Atlantic ports of Europe, but what is undoubtedly true as regards Great Britain, the north and west coasts of France, Holland, Belgium and part of Germany, is not valid when considering the Baltic, the Kattegat and the entire Mediterranean.

The construction of piers, especially the finger pier type which is often used in America, is only due to the scarcity and great cost of land. At present, however, marginal wharves are preferred, having as a rule, an apron of 40-ft. and being provided with two railway tracks.

The costs of operating modern cargo boats of medium size amount to as much as about £800 a day and delays are therefore to be avoided. On the other hand, for reasons of social welfare of the crew, there is a trend in Western Europe to minimise the stay of a ship in a port, e.g. to 48 hours, depending on the ship's size. This, in turn, will set a lower limit to the speed of unloading and loading economy, as well as to the development and number of certain crane types.

Often on certain quays, the introduction of a new freight handling system seems to be quite unfeasible, and in other cases it always proves a serious task and, therefore, an initial repugnance has to be overcome. On a certain quay in Copenhagen, however, modern level-luffing ship cranes manage transhipment into lighters while light mobile cranes and fork-lift trucks cater for the longitudinal and transversal transport on the quay apron.

In 1951, on the occasion of a strike of the dock workers in Stock-

Correspondence—continued

holm, there arose an opportunity of making comparative investigations as regards the efficiency of the ship's gear with that of the quay cranes. Mr. P. A. Hedlund, chief mechanical engineer of the Stockholm Harbour Board, stated that, when handling bulk cargo, there was a very sensible decrease of the unloading capacity. Handling general cargo by the ship's gear, however, gave much different results. In some cases the discharging speed diminished by as much as 50% of the usual, in other cases, however, the capacity of the ship's gears proved to be equal to that of the quay cranes, in spite of employing labour which was unskilled with ship's gear work. These interesting findings were published by Mr. Hedlund in No. 7/1951 of the off-prints edited by the Swedish Port Association.

Assuming that the average price of a travelling level-luffing quay crane is three times the price of a ship's modern luffing gear, and the latter about 100% more expensive than the old-fashioned non-luffing ship's gear, one gets the result that the additional expense of providing a modern cargo boat with six luffing cranes nearly corresponds to the cost of one sole modern quay crane. Furthermore, the cost of a modern and effective light mobile crane is about the same as that of a new luffing ship's gear. Hence, the provision of every travelling quay crane is equivalent to the supply of three mobile cranes. Since the average distance between quay cranes does not usually exceed 100-ft., a cargo boat 500-ft. in length needs about 5—6 quay cranes. This means that, for the amount to be invested when purchasing the above number of travelling quay cranes, it is possible to cover the difference in expenses between eight old-fashioned and eight modern luffing ship's gears and, simultaneously, to procure 11—14 effective mobile cranes.

Owing to the above-mentioned circumstances, and taking into account the enormous development of the capacity of light mobile cranes and fork-lift trucks during the last few years, one cannot help arriving at conclusions that are somewhat different from Dr. Neumann's and thus looking forward to an increased readiness to study and introduce the American system of freight handling, at least in certain parts of Europe.

Port of Stockholm,
Sweden.
2nd August, 1952.

Yours faithfully,
DR. PAUL LIEMDORFER,
M.Am.S.C.E.

South Wales Port Facilities

Poor Road Communications Affect Efficiency

By L. BRUCE MAYNE.

Apart from the geographical position of the South Wales ports—they are nearer to the West Midlands than either London or Liverpool, while the sea distances to New York, Cape Town, all Mediterranean ports, the East via the Suez Canal, Wellington New Zealand via Panama, etc., are shorter than from the two ports noted above—the facilities they offer for the shipment of general cargo are excellent. By virtue of the character of the goods normally offering for import and export through them, mechanisation of cargo handling processes has been for many years a feature of these ports, to which their respective owners have given careful consideration in the past and which policy has been continued by the Docks and Inland Waterways Executive.

Although constructed originally to deal with the coal trade, the South Wales group are now equipped with excellent cranage facilities—the principal berths being fitted with quick-acting, level-luffing electric cranes at one per 100-ft. of quay, together with other land-based and floating cranes of varying capacities—spacious transit sheds and good road and rail access to the quayside. Modernisation of certain electrical and hydraulic installations is estimated to cost more than £500,000, it being the policy of the Port Authority to look upon mechanisation as a matter which must be kept perpetually before them, losing no opportunity of introducing suitable machines whenever the need arises and circumstances permit.

Not unnaturally, the ports expect to handle the bulk of cargo produced in the immediate hinterland by the various factories set up under the post-war diversification of industry. But they look farther afield too; to the West Midlands. Unfortunately for the ports concerned not all the West Midland industries are looking in the direction of South Wales, with a view to exporting through her ports.

If more use were made of these well-situated and equipped ports on the north shore of the Bristol Channel, it would ease considerably the congestion at such ports as Liverpool and London, which, it is believed, are heavily overburdened at the present time.

It is felt that although industrialists, in certain cases, are unaware of the facilities offered by the South Wales ports, the reluctance, in the main, of West Midland firms to export through them is the poor road communications linking the two areas.

The Ministry of Transport recognised that need for substantial improvements by its ten-year plan for road development announced in 1946. As far as the Midlands and South Wales are concerned, the main features include :

(a) A branch leading from the proposed Birmingham-Bristol artery at Upton-on-Severn, 17 miles north of Gloucester, and continuing to Ross-on-Wye, where it will join the A.40.
(b) A new roadway from Almondsbury, just north of Bristol, crossing the Severn estuary by a suspension bridge and leading into Newport.
(c) In Wales, the modernisation of the "Heads of Valleys" road (A.40), the "South Wales Ports road" (A.48), and the Cardiff-Merthyr road (A.470).

Because of the economic difficulties through which the country is passing and the consequent restrictions on capital expenditure, progress of the schemes outlined above has been slowed down. Work has, however, been continued on two major schemes already begun, viz. the first section of the Neath by-pass and Merthyr Eastern by-pass, which is now open to traffic. The draft scheme for the "Ross Spin," the artery connecting the A.40 with the proposed Birmingham-Bristol road, is still under consideration.

Estimated to cost £1,500,000, the Neath by-pass is a dual carriageway road leading from Swansea docks to the River Neath, below the small town of Briton Ferry, where the river is bridged. It will be a great improvement to the A.48, being only half the distance of the present route through Neath, Skewen, etc., which is a built-up area and a single carriageway road all the way. Other plans for the modernisation of this particular road include the by-passing of Port Talbot, at the moment a particularly bad bottle-neck, Pyle and Cowbridge, and the completion of the Cardiff by-pass.

On the basis of present traffic using this road it is estimated that £3¾ millions a year would be saved by operators in running costs, through economies in time, fuel, tyres, maintenance and repairs. Undoubtedly the suggested improvements and modernisation plans would mean increased traffic on these roads with a corresponding increase in economy, although the cost of the whole scheme, including the Severn bridge, will cost something in the region of £35 millions.

Major R. H. Watling, O.B.E., J.P., director of the British Cycle and Motor Cycle Manufacturers' and Traders' Union, is reported as saying: "I believe I am speaking on behalf of Midland manufacturers as a whole when I say that we should be only too delighted if we could use the South Wales ports more. But you (in South Wales) suffer very badly from lack of road connections, while the rail services are almost too abominable to describe."

Poor communications, then, together with the complex situation of port charges, are seriously affecting the full development of the general export cargo trade from South Wales.

The principal docks of the group, Cardiff, Newport and Swansea, are becoming increasingly important general cargo ports, and it is felt that when the Ministry of Transport's ten-year plan is fully implemented and the question of port charges has been brought to a satisfactory conclusion, they will be able to compete on an equal basis with any port in the country.

Considering Dredging Craft

Recent Improvements in Design

By D. W. LOW, O.B.E., M.I.Mech.E.*

(concluded from page 110)

Suction Dredges

Dredging equipment common to all suction dredges is the suction pipe and the centrifugal sand pump. In service the suction dredge removes clay, gravel, mud, sand and silt from the bottom of harbours, rivers and other waterways, and the demand for the type continues to expand. The dredging pump, loosely termed the sand pump, is placed as far below water level as possible and it is common practice to dredge to a depth of 55 to 65-ft. below water level but less common to reach to a depth around 100-ft. As dredging increases in depth, the entrance loss to the suction pipe and the velocity head remain unchanged but there is an increase in the friction head and in the head required to support the column of mixture, which has a density materially higher than that of water. Additional means must therefore be devised to carry an adequate spoil mixture to the sand pump and this may take the form of a booster pump placed in a compartment in the suction frame.

There are three main classes of suction dredge :

The Sea-going hopper dredge;
The River and harbour dredge;
The Reclamation dredge.

Within each class there are several types but in this paper it is possible to discuss only a few.

The Sea-going Suction Hopper Dredge. This is a self-contained dredging unit having a central hopper, with opening doors in the bottom, into which the dredged material is pumped. When the hopper is filled the dredge proceeds to the deposit ground to release the load through the bottom, returning thereafter to resume dredging. An alternative arrangement is often included whereby the spoil is pumped from the hopper through an overboard discharge. The hoppers of these dredges in the course of loading spoil are always capped by a large, free water surface which, with a full spoil load, is drained off, but which, with a partial load, usually remains in the hopper, although siphons are sometimes fitted to drain this surplus water overboard. Also, if loaded with a light alluvial silt, the entire hopper content remains in a fluid state. The stability of these vessels is, of course, arranged to cope with these circumstances, as well as the possibility of the material leaving the hopper unevenly while dumping in open waters.

These hopper dredges are usually built in one of three forms, the choice being determined by the nature of the ground and the service conditions.

(a) To trail the suction pipe on the bottom while propelling ahead at low speed.

(b) To thrust the suction pipe into the bottom while moving ahead to anchors.

(c) To rest the suction pipe on the bottom while feeding downward without horizontal movement of the dredge.

In its simplest form the trailing suction dredge is purely a maintenance dredge, lifting spoil from one area, carrying it to and depositing it in another. In performing this duty the dredge works alone on the sea bar at the entrance to river or navigable channel, or in any waterway having adequate depth and length in which to manœuvre the dredge. Bar dredging is subject to frequent adverse sea and weather conditions and to accommodate the liveliness of the ship, flexible joints are introduced into the suction pipe. This method of dredging requires no moorings. The suction pipe is lowered to the bottom and, when a favourable mixture of spoil and water is obtained, the mixture is transferred into the hopper. The rate of dredge advance is controlled through the propelling machinery and the movement should be as slow as possible, preferably not in excess of 2 knots. The sand-pump vacuum guage indicates conditions in the pumping system, and the dredging depth indicator and the suction-pipe hoist rope the disposition of the suction head.

The trailing dredge will pump satisfactorily alluvial silt, soft greasy mud and sandy clay, but the best results will be secured in a free-running sand. To design a trailing, or drag, head has been the sport of many civil and dredging engineers over the years and without doubt the head exerts a dominating influence on dredging results. The shoe type of trailing head has been used successfully in a number of dredges working under widely varying conditions. It is not equipped with a mechanical agitator or hydraulic jets, but may be fitted with teeth where the ground conditions warrant this addition.

The efficiency of sand pumps ranges from 55 to 70 per cent. The spoil piping in the hull should be as direct as possible. Ground conditions, handling of the dredge, tides and weather all influence the spoil mixture in some way but if, when pumping into a hopper, an average mixture containing 20 to 30 per cent. of solids is maintained in regular service, the performance can be regarded as satisfactory.

In course of filling a hopper a substantial volume of water overflows and in certain circumstances spoil is carried away in the overflow. Many hoppers were allowed to overflow along their entire length but this method has been superseded by the introduction of weirs and overflow ducts at one end. With the spoil discharges to the hopper arranged remote from the overflow ducts and velocity of water restricted to a practical minimum, settlement of the solids in suspension is encouraged to the utmost. With heavy sands the problem of spoil loss from the hopper is not serious but with light materials the rate of settlement is slow, the carry-over high, and the difficulty of retention a major issue. As a hopper fills with spoil the intensity of loss increases until there is a point beyond which pumping is futile. One authority, dredging a light alluvial silt, operates a satisfactory procedure. Hopper doors are well maintained and tight so that the hopper may be pumped dry before dredging commences. When the hopper is filled with spoil no overflow is permitted and the dredge proceeds to dump. This scheme can be made more effective with a large capacity hopper based on spoil, weighing, say, 30 cu. ft. as against the more usual 20 cu. ft. per ton, but a larger ship is required to meet this condition, with all that implies in cost. Further, door maintenance costs could be reduced and more effective sealing retained, by the use of hopper valves with rubber landings in place of doors.

A number of different types of trailing dredges are produced: single side-pipe, twin side-pipe, bow-well, centre-well and stern-well. Some are more popular than others but there is little question that, for straightforward channel maintenance dredging, the twin side-pipe trailer is the superior craft. Adherents of the bow-well and centre-well types may however take issue with this statement. Some of the more prominent features applicable to two of the types are noted. Fig. 9 shows a recent twin side-pipe, trailing suction hopper dredge designed for river maintenance duties. The leading particulars are:

Length B.P., ft.	190
Breadth, moulded, ft.	46
Depth, moulded, ft.	18
Hopper capacity, cu. yd.	875
Dredging depth below waterline, ft.	42
Loaded service speed, knots ...	10

The length of this dredge was severely limited, as in service it is required to dredge frequently within an available length of 600-ft. This restriction permits no loss of time in handling the suction pipes and getting to work. To ensure maximum manœuvrability twin rudders are fitted behind

*Paper read before the Institution of Engineers and Shipbuilders in Scotland, in Glasgow, March, 1952. Reproduced by permission.

Dredging Craft—continued

twin screws. No bottom doors are fitted, the hopper being of the dry type, but a special arrangement of suction passages and control doors is included in the hopper through which the ship's sand pumps extract the spoil and discharge it ashore to a reclamation area.

Two 20-in. bore sand pumps are each driven by a steam engine of 500 i.h.p. placed in the pump room just forward of the hopper. Each pump is directly connected to the overside suction pipe, with suitable connections to the hopper suctions, and the discharge pipes lead either to the hopper or overboard on either side. A number of electrically-operated sluice valves are fitted into the spoil piping system. The overside suction pipes are of the rigid type intended for use only in calm waters and are raised and lowered by separate winches, driven by two-speed electric motors equipped with automatic contactor gear which selects the speed best suited to the pipe loading.

The dredging controls are located in the wheel-house which is also the dredge operating house. The telegraphs to the pump room and to the forward and after winches, the push button controls for all sluice valves in the spoil piping, the sand pump gauges, and the push button controls for the overside suction pipe winches, are arranged in one central position at the after end of the wheel-house, from which point observation of the dredging conditions is ideal.

Illustrated in Fig. 10 is a twin-screw, stern-well, trailing suction hopper dredge, arranged to pump from the bottom and to discharge either to its own hopper, which is fitted with bottom opening doors, or to a hopper barge on one side. The main particulars are:

Length B.P., ft.	212
Breadth, moulded, ft.	41
Depth, moulded, ft.	19
Hopper capacity, cu. yd.	1,000
Dredging depth below waterline, ft.	55
Loaded service speed, knots ...	10

This dredge is primarily designed for trailing work but is also required to carry out capital dredging, which necessitates the inclusion of equipment for cutter suction dredging. To perform both services adequately the stern-well trailer is the compromise craft. When trailing, difficulty may sometimes be encountered in holding the dredge to a course. When the suction frame is on the bottom it acts as an anchor and, with unfavourable tide and weather conditions, the craft may be awkward to handle even with twin screws and twin rudders ; in these circumstances the dredging performance can be adversely affected.

Between the forward end of the well-way and the after end of the hopper is the engine room, in which are the two propelling engines and one pumping engine of 425 i.h.p. coupled to a 24-in. bore sand pump. A single, compact engine-room arrangement is thus obtained but the boiler room lies forward of the hopper, which is placed as near mid-length as possible in order to minimise the extent of the changes in trim between light and load conditions.

The longitudinal hopper girder is arranged to carry the actuating gear for the hopper doors. Each of five hydraulic cylinders operates two doors, with the control valve adjacent to each cylinder on the hopper girder. The oil hydraulic system is also used to operate the sluice valves fitted in the spoil piping system. All dredging controls are centralized in the wheelhouse, from which point the operator has a clear view of the suction-frame hoist rope. The suction frame has a substantial overhang at the stern devised to enable the dredge to cut its own flotation when cutter dredging. To modify the suction frame for cutter work involves the removal of the trailing head before coupling the cutter head, the shafting, and the drive for this gear. This transfer can be accomplished within a very short time. In addition, when cutter dredging, anchors, cables and winches are required for mooring and manœuvring the dredge, which is made to traverse and "step ahead" in precisely the same manner as in multi-bucket dredging, with this difference that the stern of the ship becomes the " dredging bow " and flotation is cut ahead of the stern! On occasion, another method of manœuvring is applied to craft of this type. Two spuds, fitted forward of the hopper, are arranged in preference to manœuvring by chains only. The dredge is made to swivel about either spud and is traversed across the cut by two side-chains. No bow or stern anchor is required and the dredge " steps ahead " to the next cut by manipulation of both spuds. Advantageous when spoil is delivered overboard to a pipeline or to a barge alongside, spuds and their ancillary equipment nevertheless complicate the self-propelled craft. However, should it be necessary to discharge into the ship's hopper, they are a convenient means whereby dredging can be speedily resumed after dumping.

In the River Mersey, and in the adjacent Ribble, suction dredging has been performed for many years by dredges equipped with side pipes which face forward and are moved forward into the spoil while dredging. This mode of dredging is most successful in coarse free-running sand, favourable to securing and holding a rich pumping mixture, in which difficulties and time loss due to chokage of the suction head are very slight. Thrusting, or forward feed, suction pipes would not produce satisfactory results if used in a light silt, sludge or clay. Essentially the material must be obtained easily and flow naturally towards the suction head. In operation this type cuts a trench in the bottom, having a depth dependent upon the penetration into the bottom and a length related to the capacity of the hopper. These trenches are soon levelled out by the influx of sand deposits carried by tidal action.

Fig. 11 shows a single-screw, single sidepipe, suction hopper dredge, the main particulars of which are:

Length B.P., ft.	202.5
Breadth, moulded, ft.	40
Depth, moulded, ft.	20.75
Hopper capacity, cu. yd.	1,400
Dredging depth below waterline, ft.	46
Loaded service speed, knots ...	8.5

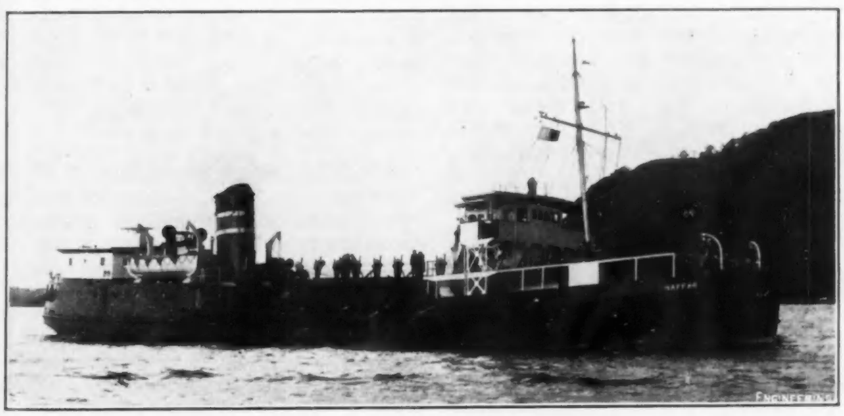

Fig. 9. Trailing-Suction Hopper Dredge *Haffar*.

Fig. 10. Stern-Well Trailing Cutter Suction Hopper Dredge.

Dredging Craft—continued

This dredge works to a strict time schedule dictated by tidal conditions. The vessel proceeds up river on the rising tide, commences dredging fully one hour before, and ceases to pump at, high tide. The deep loaded vessel then proceeds on the ebb tide to the deposit ground in the open waters beyond the entrance to the navigable channel. This cycle is repeated on each tide but, in favourable weather conditions, sea bar dredging is also undertaken.

When dredging, the vessel works to head and stern anchors, and thrusts, or feeds, the suction pipe forward. The pipe is lowered gradually into the ground to a maximum penetration around 8-ft. and is slowly advanced at that depth by taking in the head anchor chain, the stern anchor being arranged to trail. Except when dredging, the overside suction pipe is housed inboard along the starboard side of the deck. The lateral and vertical movement of the pipe, swivel joint and sliding saddle, is motivated by an oil hydraulic system controlled from the operating house on the bridge.

The hopper is equipped with six large cylindrical, rubber-seated valves, each situated to cover an opening in the hopper bottom. The oil hydraulic system already mentioned is the medium for operating these valves which are also controlled from the bridge. The hopper valve system offers important advantages in ease and simplicity of maintenance when compared with hopper doors, and in the fact that the dredge can proceed to deposit under very adverse weather conditions. Release of the spoil is, if anything, rendered more easy by a lively ship but, when hopper doors are fitted, slamming of the doors always occurs in bad weather as the spoil is being dumped; thus there is a weather condition beyond which it is unwise to empty through bottom doors. This limitation does not arise with hopper valves which, however, also have disadvantages. There is a loss of hopper capacity due to the large volume of the cylindrical valves, and the area of each opening in the bottom and the slopes of the hopper structure leading to the openings are unsuited to any material which has an adhesive or cohesive quality.

An enclosed, pressure-lubricated engine of 425 i.h.p. drives a 24-in. bore sand pump which is connected only to the suction pipe and discharges direct to the hopper. This type of vessel has a useful advantage over the trailing dredge in that the propelling machinery does not operate while dredging is in progress. In other dredges of this type only one engine is installed to drive, through clutches, either the sand pump or the propeller. Economy in fuel consumption is, at all times, an important consideration and the omission of propelling while dredging offers this feature.

To conclude these observations on seagoing suction dredges a short reference should be made to the type known, for lack of a better name, as a hole-digger. Several large and successful dredges of this type have been built for service in conditions where the material flows freely to the suction head and where there is a considerable depth of material to be removed. At the commencement of dredging the suction pipe is lowered to the bottom and the process of excavating a large hole is conducted by feeding the suction pipe downward to maintain contact with the bottom. This type is, in certain respects, akin to that shown in Fig. 11. Sea bars at the entrance to navigable waterways and composed of loose free-running sand are ideal working sites for these craft. With short hauls to deposit the spoil at sea, the ability to pump large quantities of bar sand efficiently and, in some instances, to clear a passage through a sea bar which has been closed by siltation, these vessels have proved very satisfactory. The suction pipe may be fitted in a forward or an after well-way or at the shipside but, for work on an open sea bar or channel subject to high seas and swells, it is equipped with a special arrangement of flexible jointing, so that the effects of the ship's liveliness on the dredging performance are reduced to a minimum.

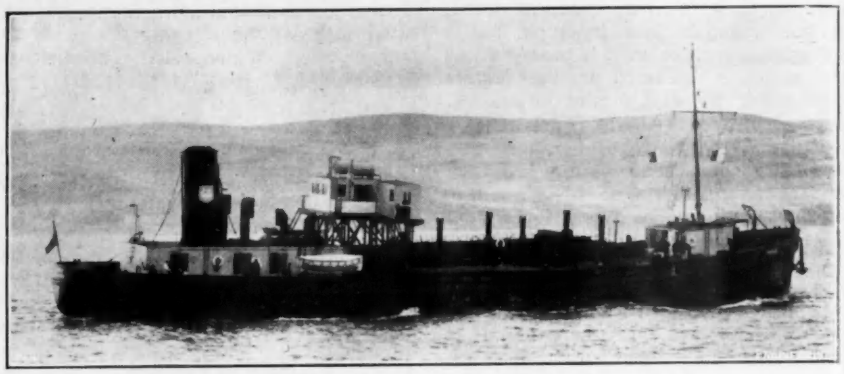

Fig. 11. Single Side-Pipe Suction Hopper Dredge *Ribble*.

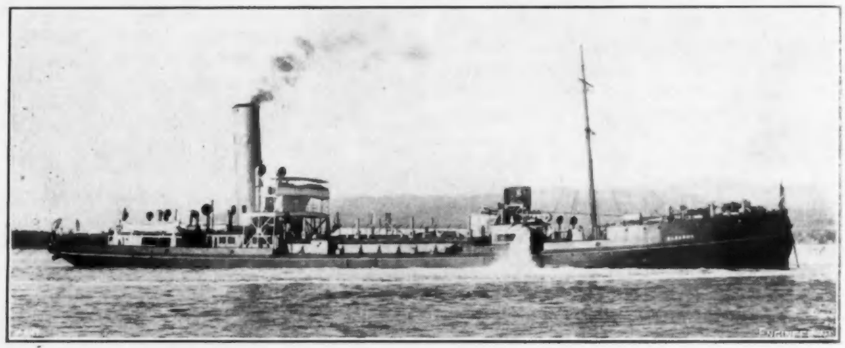

Fig. 12. Bow-Well Suction Hopper Dredge *Blesbok*.

Fig. 12 shows a dredge having closed bows and a forward well-way in which the suction pipe is accommodated with the suction head at the fore end. Between the well end and the hopper is the pump room in which two 42-in. bore sand pumps are fitted, mounted one at each end of the pumping engine and arranged so that while one pump is in service the other may be overhauled. Discharge pipes are led to the hopper and to overboard connections, and the pumping power is adequate for discharge to a distance of 2,500-ft. from the dredge. Records from this craft show that in routine service the hopper is loaded comfortably in 45 minutes, an output rate of 4,700 tons per hour. The main particulars of this dredge are:

Length B.P., ft.	304
Breadth, moulded, ft.	54
Depth, moulded, ft.	23
Hopper capacity, cu. yd.	2,600
Dredging depth below waterline, ft.	65
Loaded service speed, knots ...	12

The River and Harbour Suction Dredge.

This type of dredge is not fitted with a hopper but is arranged to pump spoil direct from the bottom, through floating and shore pipelines, to a deposit site. By preference, and as a general rule, these dredges are non-propelling, but instances do arise where propulsion equipment is considered necessary and can be arranged. Land reclamation is frequently effected by spoil disposal through a pipeline and, where areas are available and the spoil suitable, it is without doubt an excellent and economic system. Spoil disposal by means other than a floating and shore pipeline is sometimes required and one method, successfully applied, incorporates an overhung pipe system discharging overboard either to one or both sides. These dredges, on occasion, are required to work in rough waters, and for this condition the design of the floating pipeline and the joints merits particular attention.

The cutter suction principle is applied in some form to all dredges of this type. The hull is invariably box-shaped with the bows cut back in plan view, and has a well-way

Dredging Craft—continued

at the forward end in which the suction frame is partly housed. This frame, which is anchored at a pivoting point at the after end of the well-way, carries the suction pipe, the line of shafting driving the cutter, the cutter head gear, and the revolving cutter which is located at the forward end of the suction frame, substantially overhanging the bows of the dredge. The revolving cutter is the important item of digging equipment which has, by its use and development, greatly widened the scope of this type to include the dredging of clay and other hard digging materials. The cutter is usually driven independently but in small craft a combined drive is sometimes used. Power for driving the cutter varies with dredging duty and size of the dredge, but American practice far outstrips British practice to the extent that, at normal rating, 1,000 h.p. has been transmitted through the cutter with allowance for momentary peak loads of 2,000 h.p. The function of the cutter is to break down the dredging face and feed the material to the suction pipe; the design should correlate the cutter speed and traversing speed of the dredge and the cutting angle of the blades for efficient action and minimum wear.

For manœuvring it is customary to fit a multi-barrel manœuvring winch. In a headline dredge one barrel raises and lowers the suction frame, another operates the headline and four others the sidelines. In a spud dredge five barrels are used, one for the suction frame, two to raise and lower the after spuds, and two to operate the forward sidelines. A headline dredge is suittable only for easy dredging conditions but the introduction of spuds is essential for hard digging and high outputs. The spuds are located at the stern, one on each side of the longitudinal centre line of the dredge. The forward sidelines traverse the dredge back and forth across the cut and in doing this they keep the revolving cutter into the dredging face when undercutting on the digging swing. The return swing, or overrun, is usually done at higher speed and by skimming over the ground surface. In traversing the dredging face the cutter describes an arc about one grounded spud while the second spud remains suspended. Stepping the dredge ahead into the next cut is affected by a simple manipulation in which both spuds play a part and assistance is given by the sidelines.

There are several well-known designs of cutter suction dredge: (a) equipped with spuds; (b) with mooring lines only; (c) with swinging suction frame; (d) with multiple suction frames and forward feed; and (e) with rotating bucket. The first type is easily the most popular and has a wonderful record of service behind it in many parts of the world. In the United States it is used as an all-purpose dredge and the development in driving powers is remarkable. Diesel-powered installations having direct drives of 1,600 to 2,000 h.p. on the sand pump are commonplace. Above these powers Diesel-electric equipment has many operative attractions but the capital outlay is high. In large powerful dredges, discharging through a pipeline, steam plant is popular and in two typical dredges the sand pump, having a 34-in. suction and 28-in. discharge pipe, is driven by a turbine rated at 5,000 h.p. on nominal load and 6,250 on overload. Turbo generating plant supplies electric power for the auxiliaries. A large part of the installed pumping power is devoted to overcoming friction loss in the pipeline in which velocities of the order of 17 to 21 feet per second are general practice. Fig. 13 shows a 22-in. cutter suction dredge equipped with spuds and having a dredging motor of 1,000 h.p. Fig. 14 shows a small, 8-in. cutter suction dredge with spuds. The rotating bucket design is of recent date and has had, so far, limited application.

The Reclamation Dredge. The purpose of this type is to pump dredged spoil from hopper barges and deliver it to a reclamation site. Where several dredges are employed in harbour work and it is essential to carry the dredged spoil by hopper barge, which barge loads may not be deposited within a reasonable distance from the dredging site, the reclamation dredge can pump to a derelict area through a shore pipeline, and thus offers a speedy and economic means of assistance in the transport of dredged spoil. This unit is, in effect a

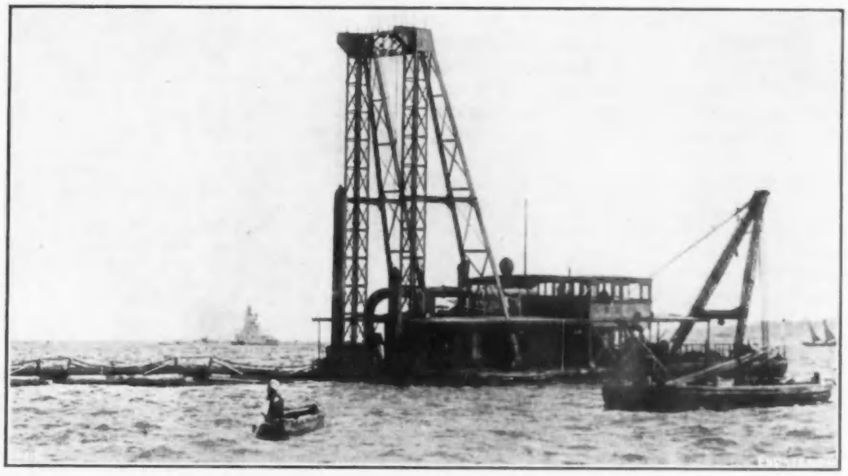

Fig. 13. 22-in. Cutter Suction Dredge *Yokohama*.

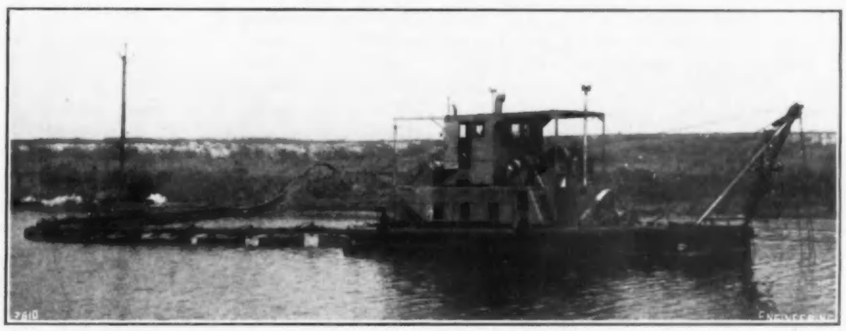

Fig. 14. 8-in. Cutter Suction Dredge.

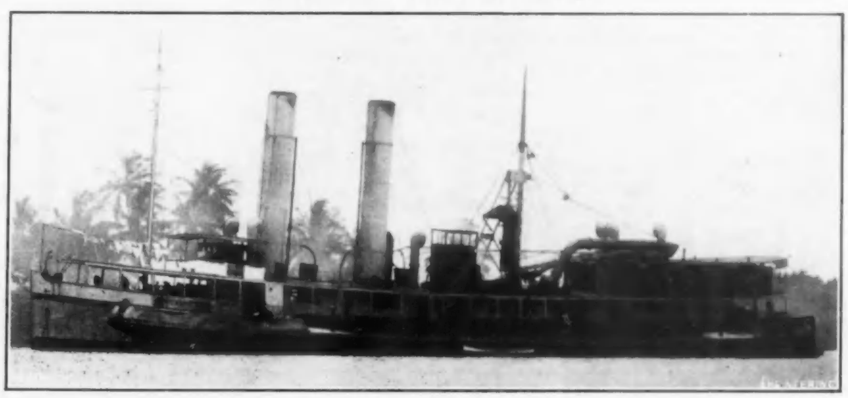

Fig. 15. Reclamation Dredge *Lady Thomson*

Dredging Craft—continued

movable pumping station. Usually two sand pumps are fitted to operate singly or in series so that long discharge pipelines may be used. Fig. 15 illustrates a reclamation dredge, designed for tropical service, in which two 27-in. bore sand pumps operate in series to deliver spoil through a pipeline 6,000-ft. in length. Usually these craft are non-propelling but a few special service vessels are self-propelled, as in this instance.

Commentary

The scope of this paper has not permitted the discussion of ancillary craft or dredging costs. Criticism may be offered to the Author's use of the word "spoil." Chambers Technical Dictionary defines spoil as: "The excess of cutting over filling on any given construction." In some conditions of dredging a spill of material returning to the bottom results in a difference between the dredged and the final depth, which material is frequently termed spoil. The word, however is used throughout this paper in yet another sense, to mean any material, dredged or capable of being dredged, a common interpretation amongst dredging men.

Rather over 50 years have passed since dredging craft formed the subject of a paper to this Institution. In the latter part of last century and for some years later, the demand for dredges expanded as great developments occurred throughout the world. Dredge builders, a forceful entity within the shipbuilding community, built craft which opened the world's waterways to ever larger ships. While the enlargement of ships continued, that of dredging craft did not. Their heyday seemed to have passed except in the American continents, where the demand for bigger and better dredges continues unabated. Much, however, remains to be accomplished in the Old World to which British engineers and dredge builders can contribute if energy and foresight are exercised.

Dredge types have altered little in 50 years but substantial improvements in detail design of equipment, and in refinements of accommodation, ship services and control gear, have occurred. Installed powers have increased but not comparably with dredge practice in the United States. Modern dredges are definitely more efficient and their ability to withstand harsh operating conditions has improved immeasurably. Wear-resisting materials and welding, the use of which has been well directed, have been an immense boon. A large field remains, however, for further research both in dredging and in the propulsion of these odd shaped craft with peculiar, but necessary, appendages to and recesses in the hull form.

Although progress has been made with Diesel and Diesel-electric installations, steam plant, in particular the steam reciprocating engine, retains a firm grip. So far as the Author is aware only one geared steam turbine dredge has been despatched from this country. This prime mover, offering best results in the higher range of powers, would appear to have a future in dredge practice. Dredging is a rugged job and dredges are frequently operated by personnel unversed in the finer techniques of Diesel and Diesel-electric machinery. They can, however, maintain simple steam plant at work and therefore could be readily trained to turbine practice. This robust simplicity of steam plant is economically important.

The Author wishes to thank Lobnitz and Co. Ltd. for their concurrence, and for the information, films and photographs placed at his disposal in preparing this paper. He also desires to acknowledge the assistance so readily rendered by several colleagues.

Appendix

Summary of Suction Dredging Results

Dredge	R	A	C	S
Hopper capacity, cu. yd.	1,400	1,400	470	470
Sand pump bore, in.	24	24	16	16
No. of tides worked	146	131	108	126
No. of tides lost—for weather	17	16	47	48
No. of tides lost—for repairs	7	11	11	—
No. of tides lost—for other causes	14	27	8	4
Total hopper load for period, cu. yd. ...	169,660	150,380	43,430	57,150
No. of hopper loads	128	112	95	118
Average hopper load, cu. yd.	1,320	1,340	456	485
Total pumping time, hr.	149.5	129.7	111.3	129.4
Time lost in clearing suction head, hr. ...	10.8	6.7	—	—
Net pumping time, hr.	138.7	123.0	—	—
Ratio: $\frac{\text{Net pumping time}}{\text{Total pumping time}}$, per cent. ...	93	95	—	—
Average pumping time per load, hr. ...	1.17	1.17	1.17	1.10
Average pumping rate, cu. yd. per hr. ...	1,130	1,130	390	440
Average mixture pumped, per cent. ...	25	25	—	—
Best time to fill hopper to capacity, min. ...	45	50	50	45
Average time to empty hopper, min. ...	25	30	11	10

The above results were recorded under regular service conditions and extend over a period of five autumn and winter months. Note the large number of tides lost by the small vessels due to weather conditions. This reflects the ability of the large vessels equipped with cylindrical hopper valves to work in conditions unfavourable to the small vessels fitted with hopper doors. Dredging was conducted between 30 and 45-ft. below water level.

The Port of Genoa—*continued*

minimum, favouring a maximum height of vertical wall in the endeavour to avoid the transformation of the oscillatory gale wave motion of deep water into a breaking wave, where in the former the wave is reflected and in the latter is projected against the walls in a liquid mass.

The depth of water in the outer harbour is 16-20 metres and in the old port generally 8 m. with the exception of the Marine Station quays at Ponte Doria where it is 11 m. which is also the depth in the Lanterna and Sampierdarena Basins. The range of tide is negligible—30 centimetres average. The greatest disturbance in the harbour rises from S.S.W. gales. There is almost a complete absence of fog. The water area of the Port is about 830 acres.

The Port Authority of Genoa is autonomous and by order of the Government is administered by a committee drawn from the towns, provinces, Chambers of Commerce, established employers of labour, and workmen. This Authority was formed in 1903 and its duration has been extended to 1973. The Law lays down that the Commission carries out the following functions:

(a) The construction and maintenance, ordinary and extraordinary, on behalf of the State, of all port works, sea defence, quays, warehouses, and mechanical equipment.
(b) Dredging of the harbour sea bottom.
(c) Illumination and cleansing of the quaysides, administration and equipment of maritime signals, excepting the main lighthouses.
(d) Construction of new railways, excepting the maintenance and charge of the National Railways.
(e) Administering warehouses and the mechanical equipment.
(f) Discipline and training of the port workers, regularising labour and the determination of the tariffs.
(g) The policing of the port, the regulation of the towing services, the mooring of vessels and other necessary port activities.
(h) The support of State concessions in all the boundaries of its territorial jurisdiction which extend from Punto Vagno to the torrent Varenna (Pegli).

The Law confers on the President, or Chairman, of the commission, who is appointed by the Government the faculty to emit ordinances in matters of Police Administration and discipline; of requisitioning assistance from the public force for their execution and, to decide disputes relative to labour and all the port operations in the limits of his competence as magistrate.

The President and a number of officials of the Commission have accommodation in the S. Giorgio palace in the old town near to the harbour whilst the executive are housed in the Maritime Station buildings on the Ponte dei Mille jetty.

The Commission provides marine services, determines the hours of labour, takes care of all loading and unloading machinery, controls all activities over the port area, water and land, administers directly or by means

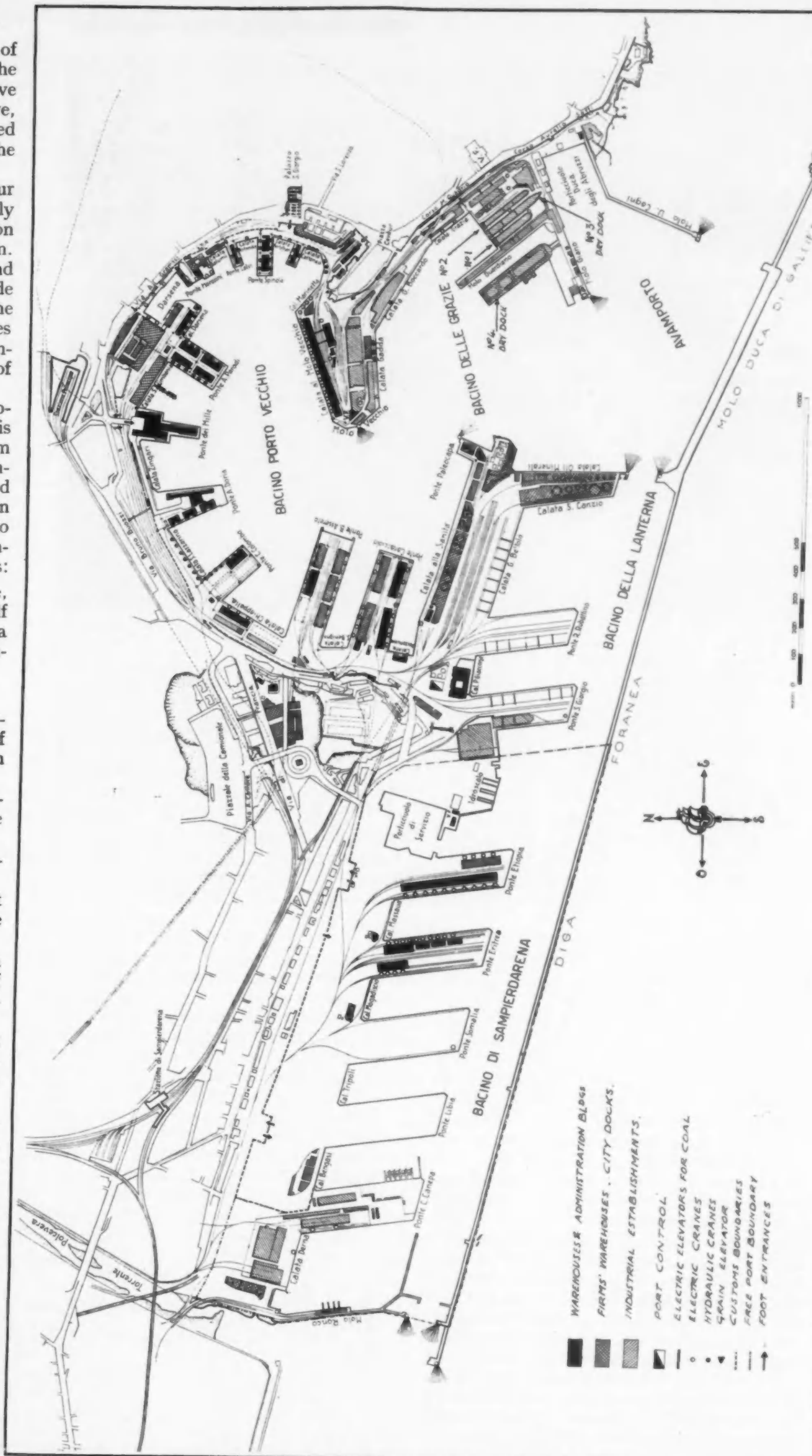

Fig. 4. The present day layout of the Port of Genoa.
(Recently the western entrance to Sampierdarena Basin has been altered to avoid the inconveniences mentioned in the text. The inner spurs have been demolished to provide a less disturbed passage to vessels during westerly gales.)

The Port of Genoa—continued

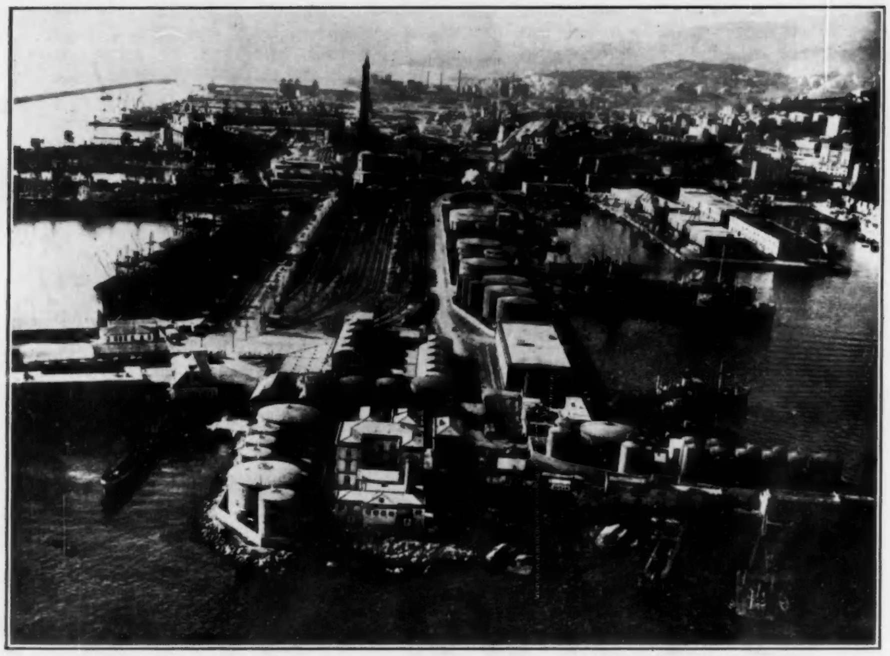

Fig. 5. Air photograph of the Lanterna zone showing the tanks on the Paleocapa jetty, the Sanita quay, and the coal transporters of the Bettolo quay in the foreground. The Canzio quay and Oil quay are shown to the left. The whole of this area commenced gradual development from the one-time New Mole of tipped rubble. In the distance the west entrance is plainly visible.

of concession, warehouses and sheds which have a floor area of 170,000 square metres including 50,000 sq. m. in concession to navigation companies. It determines the tariffs and controls all labour that may be necessary or required from Unica Merci Varie (general goods) Society, from the Pietro Chiesa Society (coal-handlers) from the Ramo Industriale Society (ship repairers) with a total of 5,200 workers on their membership roll. The Commission also agrees the clearance and movement orders of vessels which are assisted by tugs of the Rimorchiatori Riuniti Society who have 21 tugs with a combined power of 9,200 h.p. The passenger services are dealt with at the stations on the Ponte dei Mille and the Andrea Doria jetty. There are 5 vessels in use dealing with an average of 3,000 passengers daily.

Floating Equipment.

There are 44 lifting pontoons in private ownership with a maximum lift of 400 tons and a minimum of 6 tons capacity. The port also possesses 600 floating cargo barges with a combined capacity of 60,000 tons; 64 small tankers for various liquids; 82 pontoons with machinery and workshops ; 21 craft for port cleansing services; 3 bunker conveyors; a floating crane for block work of 700 tons capacity of the Soc. Pirelli.

The captain of the Port has his offices in the Station Buildings on the Ponte dei Mille. He is the Superintendent of all matters connected with incomings and outgoings of maritime traffic and has powers much in excess of a harbour master in this country, administers pilotage, sanitary police, maritime regulations and laws, naval property, fisheries, safety of vessels, arming and disarming of vessels, placings of sailors and exercises penal and civil jurisdiction.

Miscellaneous Equipment and Appliances.

The port possesses two land motor fire pumps, five complete floating fire pumps of which two can throw jets of water to 80m. high at 5,000 litres per minute and two at 3,000 litres per minute whilst the other is for express service mounted on a fast motor barge. There are water tanks on all quays, jetties and warehouses. Automatic spray fire extinguishers on the "Grinnell" system are fitted in the warehouses of the old port used for cotton goods and all the new warehouses and sheds are also equipped with the latest type of this apparatus. The telephone service embraces the whole port and the " Teti " Company connects up to all moorings alongside.

The maritime passenger station on the Ponte dei Mille houses a well-equipped information office for all public services. There are a number of loud speakers installed to assist all passengers for sending messages and information. There are also post and telegraph offices, agencies of tourist organisations and automobile clubs.

The port sanitary station is on the Ponte Paleocapa. It has a capacity of 120 beds, and is equipped with cleansing and disinfecting apparatus. A hostel in the Via Milano can accommodate 500 emigrants.

Pilotage is compulsory for vessels over 500 tons and all pilots, of which there are 20, are sea captains. There are two pilot cutters equipped with radio telephone.

The service of mooring and unmooring vessels is solely carried out by 60 skilled men who are transported about to their jobs by motor launch.

The radio telegraphic service is cleared through the Genoa-Castellaccio station of 1.5 kw. with 6 short wave transmitters.

Silos and Tanks.

The grain silos occupy an area of 7,000 square metres on the Santa Limbania quay and have a capacity of 70,000 tons. They are served by 6 suction units with a total rating of 7-8,000 tons per 24 hours. They can also deal with two barges moored abreast alongside. There are also 4 wine silos in private ownership, one on Marinetta quay, one on Darsena quay, one on Chiapella quay and one in the port basin at Sampierdarena. The total capacity of the four is 8,450,000 litres, or approximately 1,850,000 gallons.

There are also deposits for vegetable oils and animal fats, on the Ponte Paleocapa and the Sanita quay of total capacity of 5,255 cubic metres and a further 8,000 cu. m. on the Giaccone quay. A new construction on the service quay of Sampierdarena will give another 11,000 cu. m. The deposits for cotton are situated on the Old Mole and have a capacity of 100,000 bales. The

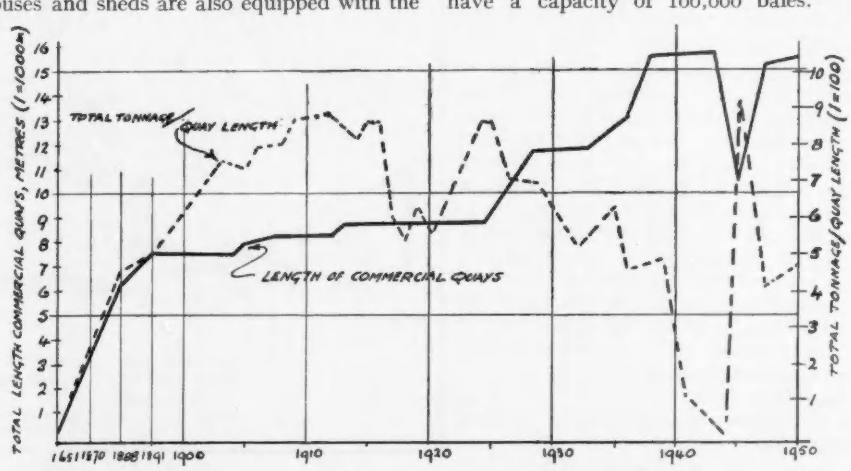

Fig. 6. Development of quayage compared to the traffic of the port (commercial).

The Port of Genoa—continued

warehouses are all mechanically equipped and have highly efficient fire protection on the " Grinnell " system.

The Port of Genoa has an existing capacity of 350,000 cubic metres of tanks for mineral oils and a further extension of 137,000 cubic metres is projected. It is also projected to construct a petrol dock at the western extremity of the Sampierdarena basin near the west entrance.

Cold Stores and other facilities.

The cold stores Zanchi are situated on the Gadda quay in the Grazie basin and have a capacity of 19,500 cubic metres for meat, fish, and sausages and the military cold stores on the Marinetta quay to the east of the Old Mole has storage for meat only of 6,500 cu. m. The municipal cold stores in old port on the Darsena quay has recently been refitted and has a capacity of 20,000 cu. m. On the Sanita quay there is accommodation for 200 head of cattle in quarantine.

On the Bengasi quay there is in construction stores and equipment to process salt, and a tobacco warehouse covering a floor space of 8,300 square metres.

The municipal dock, Darsena, has warehouses, and stores covering 40,000 sq. m. and contains a customs section, a free section, and a national section.

The free port (Fig. 4) the property of the Chamber of Commerce arises from the privileges inherited from the ancient free port in XIV century which constituted the market for merchandise from the east. The new free port has an area of 22,000 sq. m. and deals mainly in coffee, cocoa, and colonial produce.

There are four careening basins supplied with facilities for all marine purposes for fitting out and maintenance of small vessels.

The port has also no less than 80 firms specialising in marine repairs of all kinds.

On the Ponte San Giorgio there is a thermo-electric power station of the Edison Company, which supplies 170,000 k.w. yearly as reserve in the case of breakdown or scarcity of hydro-electric current, the usual source of supply.

The sporting yachtsman has the disposal of the comfortable Porticcinolo " Duca degli Abruzzi " at the extreme east of the port screened by the Cagni breakwater. All the main Italian yacht clubs have establishments there.

Quayside Facilities.

The Port of Genoa is the regular calling station for a large number of shipping lines, 40 coasters, 40 Mediterranean, 28 North European, 20 African outside of Mediterranean, 22 North American, 33 South American and Pacific, 22 Indian and the East, 8 Australian.

There are

5,210 lineal metres of breakwaters.

9,000 lineal metres of quay, 6-9 metres, depth of water.

6,780 lineal metres of quays, 9-11 metres, depth of water.

3,600 lineal metres fitting-out quays.

650 lineal metres, yachting jetties and quays.

36 warehouses, transit sheds, etc., under direct Commission control of 170,500 square metres.

7 warehouses leased to regular liners of 50,000 sq. metres.

27 warehouses in private ownership of 101,000 sq. metres.

which gives a total of

70 warehouses of 322,000 sq. metres area.

The port has also

66 hydraulic cranes of 108 tons capacity.

108 electric cranes of 312 tons capacity.

22 elevators of 107 tons capacity.

Fig. 7. The present day method of coal discharge by transporter cranes on the Bettolo quay, into trucks, bulk mounds and lorries.

23 gantry cranes (inside) of 23 tons capacity.

11 portable cranes of 13 tons capacity. making in all 230 cranes with a total capacity of 563 tons whereas before the war (1939) there were 275 cranes of 709 tons capacity. The present deficiency is due to world shortage, nevertheless, when it is recalled that 85 per cent. of the pre-war equipment was totally destroyed the recovery is remarkable.

The traffic of the port for 1950 was

arrivals 5,656 vessels of 11,900,000 tons net.

departures 5,645 vessels of 11,900,000 tons net.

Port Manpower.

The labour required for port operation can be considered from two aspects (a) specialisation and (b) organisation; (a) about 1870 there was no real sub-division of labour, each individual was one manpower; however, towards the finish of the century the mercantile movement was increased five-fold from which sprung the necessity of particular regrouping, as much for the nature and methods of handling the merchandise (coal and various goods) as for the kinds of labour and differences of skill required (mooring and unmooring a vessel, working on board —stevedoring, etc.).

Regarding (b) organisation, the first important requirement was division into categories related to the kind of labour and the degree of ability required to give efficient service. Several old associations (the oldest of which called Caravana dating from 1340) have always been recognised by the magistrates of the port. The Manna laws which abolished such associations in all Italy excepted those of Genoa, already implied recognition from the precedent of the Cavour decree of February 15, 1851 relating to the Regulations and Tariffs of the porters of the Port of Genoa. Subsequent to the promulgation of this law the six existing associations grouped themselves under the title of " Maritime Porters of Genoa " ruled by the township in collaboration with the Chamber of Commerce. But in 1874 by the Regulation of the Government through the Minister Magliani a movement was initiated to bring the interested parties together which resulted in a period of free agreement or consultation between the workers, and of the free election of the representatives for those employed in loading and unloading vessels. Nevertheless the wages remained poor and there were no fixed hours of labour. This was the most difficult period of the Port of Genoa — a period of acute and difficult struggle during a steady increase in the volume of traffic. However from this experience the modern organisation was born, which, while protecting the labourers guarantees the best development of the port operations. It was also in this period the need was felt, and the measures were initiated to form a co-ordinating and a ruling body.

From 1874 to the end of the century the

The Port of Genoa—*continued*

Fig. 8. Air photograph of S. Giorgio jetty showing in foreground the coal handling appliances; in the middle distance the electric generating station and the lighthouse are seen.

only form of port organisation was that of mutual assistance in case of need, but about 1900 there was instituted the rules of category, and the compulsory membership of the Chamber of Labour of Genoa. There also appeared various co-operatives under the denominations "Unloaders of Coal," "Merchandise Porters," "Loaders and Unloaders of Goods," this latter, the most important, began in May, 1896. At the same time the apprentices associated themselves in the "Union Enterprise Unloading, Loading and Stowing."

After the general strike in 1900, precisely in March 1902, there was agreed a first Regulation of Labour, by accord between the parties, which imposed on the employer, or contractor, to bind all personnel to the Rules. Such accord lasted only twelve months and it was only with the constitution of the Port Authority (Consorzio) that labour became finally organised.

Labour in the Commercial branches.

After the founding of the Port Authority, under a provisional ruling of September 5, 1903, in June and in August 1904 it issued the first official regulation on port tradesmen's labour to fix for every category the maximum number of workers in relation to the requirement (job) with provision of a reasonable reserve for contingencies. An outcome of this was that registers of employees were compiled officially, and held in the offices of the Authority. This constituted the Associations as de facto members each represented by one of their own elected members. It was also laid down that all work should be undertaken and carried out according to the official rules and tariffs.

Against this new Order some apprentices sustaining the necessity for a free choice made an appeal to the Council of State, which in its judgment of 1906 dismissed it, affirming that the Regulation was in the public interest.

The Regulation of 1904 presented therefore some inconvenience and unrest. As it was a provisional measure to end difficulties it was only reasonable to expect that some modification would be required according to experience gained in its working, when it could be adapted, in conference, to the situation and the times. In fact, in September 1906, even before the judgment of the Council of State, the general assembly of the Authority discussed and approved the plan of the appropriate sub-committee for the betterment of labour conditions. This was given official sanction by the decree of the President (Consorzio) on December 28, 1906.

The existing associations, as already noted, which were in fact but simple societies then organised themselves into co-operatives assuming a legal standing of more definite and precise responsibility towards the Authority, and to the employers of labour. To get a real picture of the condition of labour in the early part of the twentieth century it is sufficient to recall that about 40 per cent. of the total traffic of the port was the import of coal for which all handling was done by manual labour, ships' winches, and derricks. Beginning in 1906 a change was effected by the initial construction of coal elevators on the Assereto and Caracciolo jetties. Up till that time there were 2,000 coal humpers, today they are reduced to 420 men (Figs. 7 and 8).

After a period of trial of the Rules established by the Ordinance on Labour (1906) to the contingent exigencies and seeking for ways and means to render it more suitable to its smooth working there was instituted in 1913 a permanent Committee of Labour. This body caused to be issued a Regulation solely applicable to coal in bulk (1915).

In the period following the first World War and the advent of fascism the men's associations became disrupted. With reference to the Instruction R.D.L. October, 1923 a new Order was issued on port labour by which the Co-operatives of port workers were reconstituted. They assumed the legal position of "Co-operatives of Labour." Eventually after the elections these were transformed into Associations based on

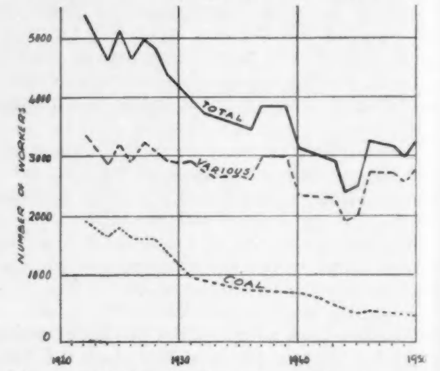

Fig. 9. Graphs showing the number of workers on the port register of labour (commercial branch).

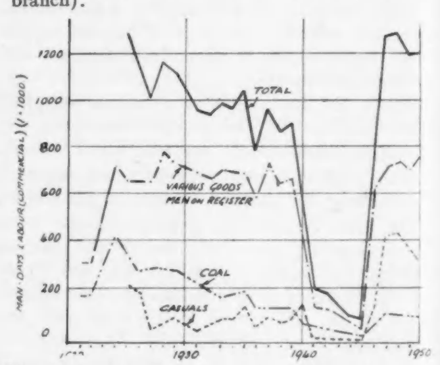

Fig. 10. Graphs showing the man-days of commercial branch labourers, casuals, coal, and mixed merchandise.

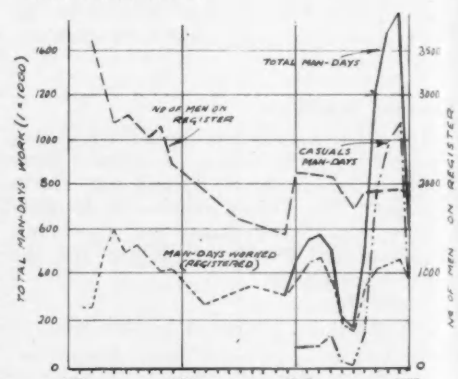

Fig. 11. Graphs showing the man-days of industrial workers, casuals, and registered workers.

The Port of Genoa—continued

R.D.L. January, 1929 which reformed the formations of port workers corporations in all Italy, and gave a definite order regarding the establishment in Associations. From this there was developed the last "General Ordinance of Labour," still in force, approved by Decree, April 1930.

However although the said Order remains substantially unchanged, after the second World War several notable modifications have been made in the organisation of port labour.

For the bulk coal branch of labour there has been little change; it remains substantially as it was before the war. On the other hand the various branches of general merchandise labour after the liberation underwent a radical transformation. They regrouped themselves in a single organisation called "Union solely for workers in general merchandise" included in which the various sections still keep their identity of category corresponding to the old set-up, even to the luggage porters.

After the liberation the 28 enterprises dealing with loading and unloading who were disciplined to the rules and tariffs of the port because of the deficiency of barges and tugs and also to the fact that the Allied Military Government only wished to deal with a single entity were united in E.G.I.S. (Administrative Body for Loading and Unloading). This body thus shouldered the confidence of the Port Authority and complete responsibility as direct contractors of all the operations of loading and discharging of vessels. Thus the functions of the undertakings, for the various goods in kind, was then exercised through the E.G.I.S. whilst for the bulk goods, excepting coal, the contractors were represented by the Association solely for general merchandise known as C.U.M.V.

Eventually when things again became normal E.G.I.S. was dissolved, and the freedom of enterprises re-established with agreed rules relative to a minimum of mechanical plant under the control of the proprietors of warehouses etc., held by legal concession (decree February 23, 1949). As far as embarkation is concerned this has been allotted to S.A.I. (Society for Embarkation) controlled by the appropriate committee of the Authority.

Fig. 12. Aerial view of the ship repairing area in the lee of the Giano Mole (compare with Fig. 4). In the middle distance the tongue butting into the Old port is the present day appearance of what was once the Old Mole. Beyond, at the top of the picture, is the ancient port.

Up to the end of 1924 the only provident scheme of the port workers was in the hands of a single society, and the only financial support was the collection of small contributions which served to grant a little needed help to workers no longer fit for labour either by age or sickness. By decree February 26, 1924 there was founded by the Port Authority an official body (U.A.P.L.P.) formed solely to provide a provident fund of greater financial resources and security. It is supported by contributions levied by a percentage of the tariffs on the goods handled. It has been highly successful and though originally reserved solely for commercial port workers it has now been extended to cover workers in industrial branches. Actually, at the present time, this body provides payment for 2,036 workers' pensions, 882 invalids, and 1,933 widows and orphans of workers.

Industrial Labour.

The organisations of the unions of the industrial branches of labour were formed before 1900 in a co-operative form for some categories; but it is only since the Port Authority was founded that a definite and orderly arrangement has been achieved. The administration provides and holds a special register for every category of labour and furnishes assistance.

Under the provision No. 918, August 1922 there was a revision of the register. In 1928 the Associations were reconstituted and amalgamated in the "Association of Industrial Labour" with the exception of the "Association Carenanti." Following this there was little change excepting of course periodical revision of the Register and of assistance.

For all the labours of repair, maintenance, alteration and demolition of merchant vessels the interested enterprises must engage their labour from those on the register, of the 23 categories of which the Association is formed. Labour on Italian war vessels is not subjected to the rule. However in Genoa there is agreement that the apprentices, or casuals should belong to a union or organisation of highly specialised tradesmen, or craftsmen, if only for the period to carry out the determined work, with at the same time, guarantees to the workers of the observance of the appropriate contracting standards, and the full benefit of the provident organisation. The graphs (Figs. 9-11) of the number of workmen on the register and the development of the work days gives a clear indication of this particular section.

The growth of the ship repairing facilities has been of paramount importance to the harbour and of great advantage to maritime interests. There are four dry docks, 930, 860, 700, and 600 feet long respectively snugly placed in the south east corner of the Grazie deep water basin (Fig. 12). Nos. 1, 2 and 3 lie between the Grazie quay and the fitting out quay called the Guardiano mole and No. 4 lies in an isolated position west of No. 3 and separated from it by the fitting-out basin. The dock is of the self-stable type keying into the base mattress.

The Port of London

Some Engineering Aspects of Post-war Reconstruction and Development

By N. N. B. ORDMAN, B.Sc., A.M.I.C.E.

(Concluded from page 136)

General Engineering Details

Apart from the prestressed concrete portal construction referred to above, conventional reinforced concrete or steelwork has been used throughout. In 1950 the standard specifications were revised. and the section dealing with concrete brought into line with the latest practice. Water-cement ratios, aggregate-cement ratios and aggregate gradings are specified. The aggregates used are "as raised" river ballast, adjusted by additions as required, for the lower strength concretes, and rounded river gravel or granite for the higher strengths. The aggregate gradings in "Road Note No. 5" are followed. The granite aggregates which are very expensive in the London area, are used only for pavings, such as floors, roads and quays, which must take heavy wear and abrasion. The minimum crushing strength normally specified does not exceed 3,750 lbs. per square inch.

Concrete Roads and Pavings

In road paving, use has been made of an interlocking joint, particularly where poor sub-soil conditions have been encountered, mainly in the Royal and Tilbury Docks. In the latter the ground conditions are particularly troublesome; a gradual sinking being general over the whole area. Quays, lock walls and buildings are founded on piles or cylinders driven down to ballast or chalk at a depth varying from 50 to 70-ft. An extensive programme for the reconstruction of the roads in this dock is now being undertaken. The paving is an average of 6-in. thick, reinforced with suitable mesh reinforcement. In order to reduce the loading on the subsoil to the required limits, the paving is laid on about 12-in. of hardcore on 3-in. of rolled ashes, this depth having been arrived at as a result of soil tests. In an attempt to overcome difficulties arising out of the tendency of the floors of transit sheds to sink, trial sections of floor have been laid with pre-cast reinforced concrete sections arranged so that they can be lifted and packed up with sand as required.

"Lead-in" Jetties

A feature of the London river is the "lead-in" jetties or piers which flank the approaches to the entrance locks. A typical example is the entrance to King George V Dock shown in Fig. 12. These jetties have several important functions. They act as a baffle to tidal currents which may run at speeds up to four knots; they are provided with fair leads and bollards for mooring ropes, and they provide a buffer on which ships and craft may "lean" as they make an entrance. In exceptional circumstances they may prevent a vessel, temporarily out of control, from running aground. To carry out these functions the jetties must be very strong, yet elastic. Were they of rigid construction, e.g. mass concrete, they would undoubtedly cause considerable damage to vessels.

With one exception these jetties are constructed of timber and the author considers that timber has advantages over any other form of construction for this specific purpose. Despite its high temperature, the Thames, particularly in the upper tidal reaches, is comparatively free from the marine animalculi which cause timber erosion. The use of greenheart or basra-locus and proper impregnation with preservatives gives further insurance against attack and rot "between wind and water." Thus, the disadvantages under which timber may suffer elsewhere are reduced. The main advantages are in the resilience of timber structures and the comparative ease and economy with which local damage can be made good. Under a very severe blow the joints in the region of impact may give and thus prevent more serious damage. Where piles are snapped off they can be scarfed and "jumped."

Serious damage has been sustained by four "lead-in" jetties during and after the war. The repair of these damages has proved lengthy and difficult in much used entrances, and temporary dolphins and booms were erected behind which the work was carried out.

In the case of the Blackwall Entrance Lower Pierhead, where the timber structure had been almost completely destroyed, a type of construction developed by the Admiralty during the war has been used (Fig. 13). This type of construction is designed to give a high degree of energy absorption. The structure can deflect to a much greater degree than other forms without damage to itself,

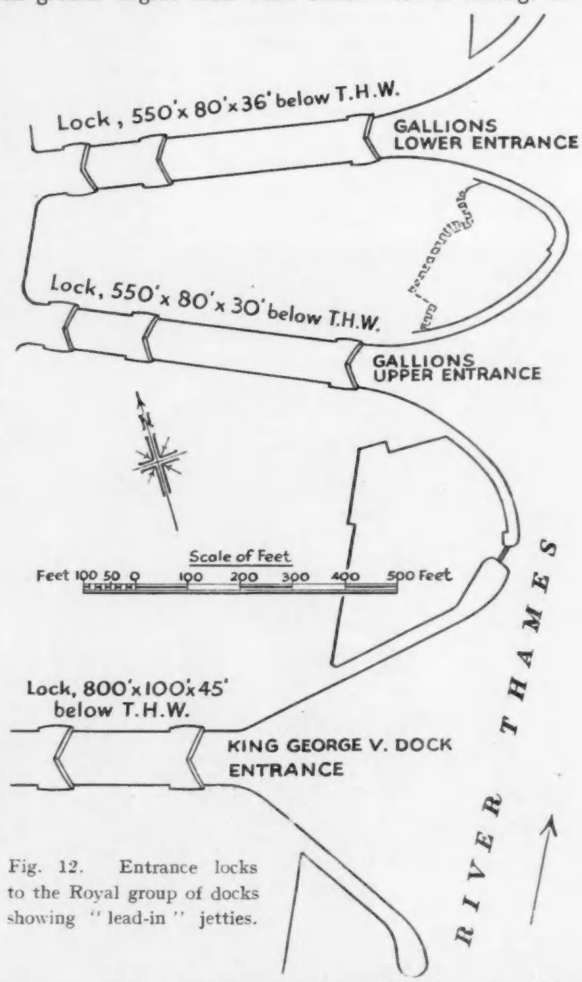

Fig. 12. Entrance locks to the Royal group of docks showing "lead-in" jetties.

and can thus absorb the kinetic energy arising from a collision with less likelihood of damaging the vessel involved. The steel box piles have a higher section modulus than concrete or timber piles of comparable section. The thick concrete slab forming the cap contains comparatively little steel and greatly simplifies the formwork requirements. It has four main functions: it forms the deck of the jetty; it conveys the blow from any one spot to several piles; it "fixes" the top of the piles and thus increases their resistance to bending, and finally it gives weight to the structure and thus increases its capacity to absorb kinetic energy. A disadvantage from which this type of construction suffers is that, should a pile be broken or badly damaged, its replacement would present a difficult problem.

The Port of London—continued

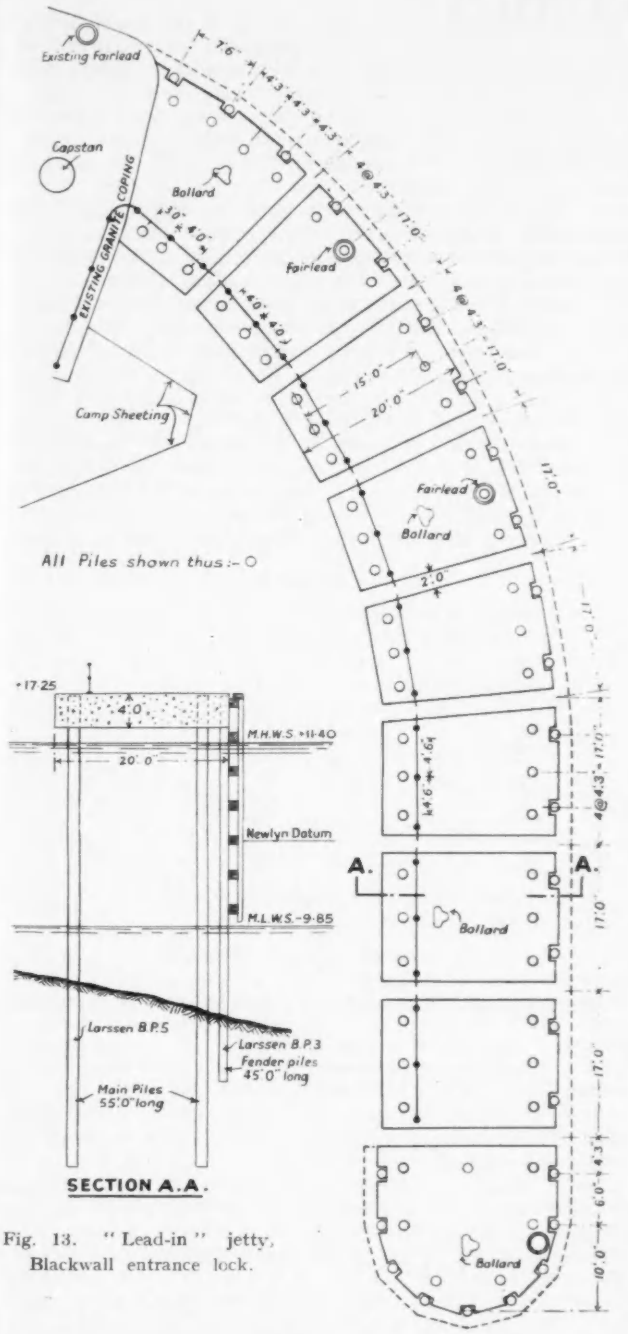

Fig. 13. "Lead-in" jetty, Blackwall entrance lock.

Cranes

The most important mechanical unit in dock operating is the quay crane. The Authority operate both electric and hydraulic cranes, but are now standardising on the former. The majority of quay cranes ordered since the war are rated at three tons and have a maximum radius of 65-ft. Others have a maximum radius of 80-ft. Other details are: Hoist speed 300-ft. per minute, luffing speed 120-ft. per minute, slewing speed $1\frac{1}{2}$ r.p.m. A number of five ton cranes with a maximum radius of 80-ft. has been ordered also. The comparable figures are 200-ft. per minute, 120-ft. per minute, $1\frac{1}{4}$ r.p.m.

It is not proposed to enter into a discussion concerning the rival merits of electric and hydraulic cranes, but there can be little doubt that electric cranes present less difficulty in the matter of power supply to the extent that it is easier to lay and accommodate an electric cable than a hydraulic main. The normal practice in the Port of London Authority is to run the supply cable to switch boxes mounted on the walls of the sheds. A flexible cable from the crane is laid in the recess between the crane rail and the rail guard, thence into a channel running transversely across the quay to the shed wall, where it is plugged into the switch box. In the quay being reconstructed at the Eastern Dock, London Dock, referred to earlier (Fig. 11), the switch boxes are fitted in pits in the quay.

It will be noted that in this scheme and in the Shadwell scheme three crane rails have been laid to accommodate cranes of two different gauges. The electric cranes have a 13-ft. 6-in. gauge and the hydraulic 10-ft. 1-in. Although no new hydraulic cranes have been purchased since 1927, a large number are operating at full efficiency and will continue to do so for many years to come. It is thus necessary to provide for their continued use in those docks where they are most suitable and also for the electric cranes which will eventually replace them.

For lowering goods out of the upper floors of warehouses the simple and effective "jennie" wheel is still supreme. Wall cranes are provided for hoisting goods into the warehouses, all post-war warehouses being fitted with electric slewing and luffing wall cranes of up to 30 cwt. capacity with outreach of as much as 30-ft. (Fig. 9). Greater use is now being made of powered hoists attached to overhead beams cantilevered out from doorways in the upper floors (Fig. 14).

By far the greater part of the electrical equipment used is D.C. Both A.C. and D.C. supplies are received from the electricity undertaking and are converted and transformed as necessary.

Fig. 14. Powered hoist operating on cantilever gantry, for loading and discharging direct from upper floor of warehouse.

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Fig. 15. Photograph taken inside the diving bell during repairs to the cill of St. Katharine entrance lock. The level of water in the bell has been reduced to about 1-in., as can be seen from the diver's fingers.

Rails

The rails used for cranes and railways in post war construction are flat bottomed and weigh 90 lbs. per yard run, which is the section now adopted as standard by the Authority. The 75 (R) section which was the standard prior to the war has proved adequate hitherto, but in view of the steadily increasing loads from crane wheels a more robust section was considered advisable where new tracks are being laid or replacements carried out. The 90 lb. section has been selected from considerations of strength, availability and the relationship between strength and weight (and thus price). Availability is a serious consideration. It was necessary to select a section for which there is a considerable demand, as the mills cannot set up the special rolls required to turn out the comparatively small quantity needed by one undertaking. The 90 lb. section, though not used by British Railways, is rolled in this country for railways overseas and for other dock undertakings. Other considerations that had to be taken into account were that the difference in height between the new rail and the old was not such as to cause constructional difficulties when replacements were necessary, and secondly that the width of the railhead was such as could be accommodated by the wheels of existing equipment. Details of the rail sections were given by Mr. H. F. Cornick in his article on "The Lay-out of Dock Railways" in the May issue of this journal in which he also referred to elastic rail spikes now being increasingly used by the Authority. Considerable use is also being made of pre-stressed concrete sleepers.

Locks

All the Authority's dock systems are impounded, thus the importance of locks adequate in length, depth and width and efficient and dependable lock-gates, sluices and machinery can hardly be over-estimated. The Authority are engaged on a very comprehensive programme of repairs to locks and repairs or replacements of lock gates and machinery. They operate a total of 30 locks with 62 pairs of lock gates. The number of lock gates that have been, or are to be, taken out for overhaul in the current programme is 30 pairs and the number of new gates under construction or shortly to be constructed is 12 pairs. From this it may be appreciated that the programme is too extensive to be dealt with in this resumé except with the briefest references. The difficulties of lock repair, entailing as they do a great deal of underwater work, will be only too well known to maritime engineers. The programme requires the frequent use of limpet dams, divers and a diving bell. Fig. 15 is a photograph taken inside the bell during repairs to the outer cill of St. Katharine Entrance Lock. The bell, which weighs 16 tons and is 10-ft. 8-in. x 6-ft. 4-in. x 6-ft. 6-in. high, was built in 1937 when it was used in the deepening of the Connaught Road Passage in the Royal Docks.

The existing lock gates which are all of the double-leaf mitre type, are either single skin curved gates with spear rods and rollers, operated by chains, or tank gates with or without rollers operated by direct acting rams. All the gates being constructed since the war are welded steel tank gates operated by direct acting rams. Apart from some minor gates in small locks and cuttings all the gates are operated by hydraulic machinery. The use of electrical machinery is now being considered.

An ever present consideration for those responsible for dock undertakings is the adequacy of the entrance locks to the dock systems to accommodate the varying beams, drafts, lengths and shape of the vessels using them. The Authority insured their position for some years to come by the construction of the new entrance lock at Tilbury, opened in 1930, which is 1,000-ft. long by 100-ft. wide, and has 45-ft. of water on the cill at Trinity High Water, and the King George V Lock in the Royal Dock which was opened in 1921 and is 800-ft. long by 100-ft. wide and has a depth of 45-ft. over the cill at Trinity High Water.

The need to carry out extensive repairs to the Lower Gallions Entrance Lock at the Royal Docks has given the Authority the opportunity of further improving the access to this important dock group by squaring off the existing rounded invert of the lock, thus giving it greater effective depth. This work is now in progress.

Conclusion

In the above an attempt has been made to indicate the wide scope of the reconstruction being undertaken by the Port of London Authority and to set out some of the problems which arise. These problems are doubtless familiar to dock engineers who may be interested in the methods being used to overcome them in London.

The author wishes to acknowledge his debt to the Chief Engineer, Mr. W. P. Shepherd-Barron, for permission to publish this article; to the Deputy Chief Engineer, Mr. G. A. Wilson, M.Eng., M.I.C.E., M.I.Mech.E., the Divisional Engineers and their Assistants, and in particular to Mr. W. Hall, B.Sc., M.I.C.E., A.R.I.C.S., and Mr. A. S. J. Campbell, B.Sc., A.M.I.Mech.E., for advice and information.

The views and opinions expressed in the article are the Author's and not necessarily those of the Authority.

International Association for Hydraulic Research

An important international technical conference has been arranged to be held in Minneapolis, U.S.A. during the first week in September, 1953, between the International Association for Hydraulic Research and the Hydraulic Division of the American Society of Civil Engineers.

At this meeting, the following subjects will be discussed: 1, Density Currents; 2, Air Entrainment by Flowing Water; 3, Waves, Beach Erosion and Hydromechanics of Shore Structures; 4, Basic Relationships of Sediment Transportation by Flowing Water. Papers on these subjects will be welcomed and directions for their preparation and presentation may be obtained from St. Anthony Falls Hydraulic Laboratory, Minneapolis 14, Minnesota, U.S.A.

The International Association for Hydraulic Research was organised in 1935 to stimulate research and the international exchange of information relating to work done in the general field of hydraulics. This exchange has been accomplished through biennial meetings and the publication of periodic summary reports of the progress achieved.

The international meetings have usually been arranged in connection with meetings of the World Power Conferences, Congress on Large Dams, or the Permanent International Association of Navigation Congresses. The most recent meetings have been held as follows: Stockholm 1948, Grenoble 1949, Bombay 1951, for all of which the technical proceedings have been published. The international Association for Hydraulic Research also issues annually a Bulletin on current hydraulic research throughout the world, exclusive of the U.S.A., a bulletin for the latter being issued by the U.S. Bureau of Standards.

Port Economics

Part 10. Miscellaneous Matters

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THE PURPOSE of this general chapter is to deal with a few miscellaneous matters each of them having some actual or potential bearing upon the economics of port undertakings. It has been suggested to the author that it may be useful for students to have a general note on each of such subjects as taxation, rating, insurance, free ports, ancillary services, port associations and pilferage.

Taxation.

Although United Kingdom port undertakings are so often, by constitution, non-profit-making, public utility undertakings, their surplus revenue, if any, is subject to income tax, profits tax and the excess profits levy. They are taxed upon the annual value of any miscellaneous properties they hold, and also upon the income from money saved and invested as reserve funds outside the undertaking. They are liable for tax upon any rents paid to them by the occupiers of land upon the port estate. They act as collectors of tax for the Exchequer by deducting and handing over tax at the standard rate from the interest they pay to bondholders and other classes of investors who have lent money to the undertaking. If a port authority has ground rents to pay, tax is similarly deducted and handed over. Port authorities are also concerned with income tax in the matter of making accounting arrangements to operate the pay-as-you-earn system in respect of their employees.

The tax liability of a port authority—like that of any private enterprise trader—is determined by the Finance Acts. Some particular effects of the Finance Act 1952 are noted hereafter.

For the purpose of assessment under Schedule D, one system with which the author is familiar is for the authority to prepare an income tax computation based upon the audited accounts of the last financial year. The computation, having been agreed with the inspector of taxes, forms the basis for assessment for the fiscal year following that in which the financial year ends, the income tax being due for discharge on the following 1st January.

The computation begins with the total income for the financial year under review from which is deducted the year's working expenses (other than interest on public debt, stamp duty, loan charges and capital redemption). This net figure is then adjusted for any special debits or credits included, being increased in respect of any disallowable or taxed items included in working expenses and decreased in respect of taxed income (e.g. rents, acknowledgments, etc., paid under deduction of tax), Schedule A assessments on property (the income in respect of which is included in total income) and the like. The resultant total represents the adjusted profits and is subject to further deductions in respect of

(1) industrial buildings allowance.
(2) plant and machinery allowance under section 15 (1) of the Income Tax Act 1945.
(3) losses brought forward from previous years (Rule 21 assessment).

The allowance relating to industrial buildings and the initial allowance on plant and machinery were first provided for in the Income Tax Act 1945. Since the introduction of that Act, capital expenditure upon a new industrial building has been attracting an initial allowance of one tenth to be allowed in charging the profits for the year of assessment; in the initial year and thereafter an annual allowance is to be made equal to one-fiftieth part of the expenditure (for 45 years) the notional life of a building being taken as 50 years. Annual allowances (for the unexpired part of the 50 years' period) are also obtained on industrial buildings constructed less than 50 years prior to the passing of the Income Tax Act 1945. The initial allowance in respect of machinery and plant was fixed at one-fifth in 1945 and raised to two-fifths in the case of expenditure incurred on or after 6th April 1949. The annual allowances (grossed to five-fourths of the basic) can range between 5 and 20 per cent. of the expenditure according to the type of machinery.

No initial allowance is to be made in respect of expenditure incurred on or after the 6th April 1952.

The final assessment for Schedule D purposes can now be ascertained. Commencing with the adjusted profits figure mentioned earlier, reductions are made in respect of allowances relating to buildings, machinery and plant, and also any losses brought forward from previous years.

The Rule 21 assessment is another computation which requires to be agreed with the inspector of taxes. Such an assessment only arises in those concerns where the total taxed payments (including interest paid on public debt and other annual payments, etc.) reduced by the total taxed income (including rent, Schedule A assessments, acknowledgments etc.) during the fiscal year, i.e. 6th April of one year to 5th April of the next year, exceed the figure of adjusted profits computed on the normal basis of the preceding year, less allowances and any losses brought forward.

Where these circumstances prevail, an assessment known as a Rule 21 assessment is made for the greater amount, and the difference between this latter amount, and what would have been the normal assessment on the preceding year's basis is carried forward as a loss to be set off against future assessments. The present standard rate of income tax (October 1952) is 9s. 6d. in the pound.

Profits Tax.

This is the modern form of the national defence contribution introduced in 1937 which underwent considerable amendment in 1947 and 1951. Until the 1st January 1951, public utility and statutory undertakers were exempt. With effect from the 1st January 1952, the rate of duty on profits not distributed was reduced from 10 per cent. to 2½ per cent. The basis of computation is as for income tax but deductions are allowed in respect of interest, annuities and other annual payments, patent royalties and rents, but not in respect of the annual value of premises and/or lands occupied by the port or dock authority for its own purposes.

The duty is now not allowed as a deduction for income tax purposes (Finance Act 1952).

The Excess Profits Levy.

This is a new tax introduced by the Finance Act 1952. Where the profits for any chargeable accounting period exceed the "standard" profits—explained later—there is to be charged in respect of the excess a tax to be called the excess profits levy, equal to 30 per cent. of the excess. The levy is to commence as from the 1st January 1952 and is in addition to income tax and profits tax. In computing any income, profits or losses for the purposes of income tax or profits tax, no deduction may be made on account of liability to pay, or payment of, the excess profits levy.

The basic method of assessing the standard profits is by reference to the actual profits during two specified years, authorities having power to elect which of the following years shall be taken, namely, 1947 and 1948, or 1947 and 1949, or 1948 and 1949. The standard profits are one-half of the profits for the two years selected with a minimum of £5,000. Alternatively, a port authority may elect that its standard profits shall be calculated by another method altogether. Any authority may elect that the standard profits shall be an amount equal to 8 per cent. of the amount by which at the end of the year 1946 or 1951 (as may be specified in the election) the value of the assets computed in accordance with the provisions of the 8th Schedule to the Act exceeds the amount of the

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liabilities so computed. In addition, there are special alternatives available to authorities having a share capital.

There is an important rule as to the effect of borrowed money. Where standard profits are calculated by reference to actual profits and the average amount of borrowed money in a chargeable accounting period exceeds the average amount of borrowed money during the standard years, or is less than the average amount of borrowed money during the standard years, the standard profits for the full year shall be increased or decreased, as the case may be, by an amount equal to 4 per cent. of the difference. Where the standard profits are otherwise calculated, the standard profit for a full year is increased by an amount equal to 4 per cent. of the average amount of the borrowed money in the chargeable accounting period except where the standard profits are taken as the minimum amount, namely £5,000.

Generally, the profits or losses for the purposes of the excess profits levy are to be computed as for the profits tax subject to certain modifications set out in the 9th Schedule of the Act; statutory sinking fund contributions are deductible provided the authority pays fixed rates on its borrowings and possesses no share capital. Authorities may claim repayments in respect of a deficiency of profits—a deficiency being the amount by which the profits in a given year fall short of the standard or, in the case of a loss, the sum of such loss plus the standard. There is an overriding limit on the amount of levy payable from its inception—the limit being 15 per cent. of all profits made; relief under this limit is provisional and similarly adjustable in future years.

Rating.

The basic principle of local rating is that every occupier of property within the boundaries of a rating authority is liable, under the Rating and Valuation Acts, to be assessed for rates on a valuation of the occupied hereditament based on the rent that a hypothetical tenant would pay. Public utility undertakings, including port, dock and quay authorities are included within the scope of the Rating Acts, and rating authorities therefore put a rateable value on such undertakings and require the occupiers to pay rates at such sum in the pound as may be fixed by the rating authority in any year.

Prior to the passing of the Local Government Act 1948, the duty of making valuations for rating rested with the rating authorities but it was the practice of many rating authorities to employ professional valuers to do the specialised work of valuing public utility undertakings.

It is generally understood that a common principle of valuation was to take the gross income of the undertaking and first deduct the working expenses (including any interest on loan capital but not dividends on share capital). A further deduction was then made representing, in the opinion of the valuer, a fair return to the hypothetical occupiers for their services in operating the undertaking. The resultant balance—if any—was then taken to represent the sum of the net annual value and the rates to be paid.

In order to arrive at the rateable value (that is the figure on which the rate in the £ is payable) certain statutory deductions must be made for port, dock and quay undertakings. In the case of County Boroughs and urban districts a percentage deduction, which varies over different rating authorities, is allowed from the net annual value of "land covered with water." Broadly speaking "land covered with water" means wet docks, canals, pontoons and reservoirs. It does not include dry docks occasionally covered with water. A further 75 per cent. deduction is made from the net annual value of industrial and freight transport hereditaments, usually termed "de-rating," by virtue of the Local Government Act, 1929, and "land covered with water" may be subject to both deductions. This is still the law and as a very large part of the property of port and dock undertakings comes within the freight transport hereditament classification, such undertakings get the advantage of this de-rating.

It is possible that a valuation computed on the aforementioned basis might result in a nil assessment. In such a case, the "contractor's principle" was applied. By this method, it would be argued that despite the absence of profits in a particular year the undertaking must have some value and another (hypothetical) tenant might have made it pay. The capital value of the undertaking would then be computed and anything (say) from 3 to 6 per cent. on the capital value might be regarded as evidence of the net annual value.

Valuations for rates have normally to be revised every five years but the war of 1939-45 interrupted the ordinary sequence and, by a provision made in the Local Government Act, 1948, the valuation functions of rating authorities were transferred to the valuation department of the inland revenue. It is understood that one of the reasons for the change was to aim at uniformity of assessments throughout the country especially because local rateable values are closely linked with Exchequer grants to local authorities. The work of the re-valuation under the new arrangement is now proceeding (1952).

Insurance.

Port and dock authorities spend substantially, every year, upon insurances of one kind or another. On the other hand, if the undertaking is financially strong, the trading outlook well assured and accident experience over a term of years not outstandingly bad, the authority sometimes decides to "carry its own insurance" in respect of certain classes of risk. It is usual, however, to find authorities paying annual premiums for insurances against fire, common law liability in respect of injury or loss of life amongst the workpeople, third party risk generally, loss of or damage to craft including marine third party risk, damage to cranes and other machinery including the service of periodical inspection and report, and the expenses of wreck removal. With special reference to the last item, it is often the case that a port authority has the statutory right to require the owner of a wreck to remove it and, if he fails to do so, the further right to do the job itself, charge the owner, sell the salvage if he does not pay and to proceed against him if the authority is still out of pocket. But the removal operations may be long, difficult and costly, the salvage of little worth and the owner without money, and, in such a case, a wreck removal insurance policy would be very valuable.

Some authorities are still insuring their craft against possible damage or destruction by mines; and, in the United Kingdom, war damage in the ports was dealt with under the War Damage (Public Utility Undertakings, etc.) Act 1949. The total amount of war damage sustained by the undertakings comprising the harbour group was assessed at £28,623,184, and the agreed contribution liability of the group was fixed at 10 per cent., that is £2,862,318. The 10 per cent. contribution was apportioned by agreement over the members of the harbour group on the basis of their assessments for Schedule D income tax averaged over the last three pre-war tax years.

Free Ports.

A fairly full note on this subject will be found in Chapter 10, commencing on page 251 of the companion volume (Port Operation and Administration—Chapman and Hall). One of the most recent references to the matter was made by the director of the port of Rotterdam who, in the course of a speech on shipping turnround, remarked that they had considered the creation of a freeport zone but had rejected the idea because the normal Customs routine proceeded so smoothly that, in practice, Rotterdam is freer than a freeport.

The ultimate tests of the free-zone system are in relation to practicability, cost, speed in cargo-handling, the turnround of shipping and the volume, actual and potential, of the port's trade. There is an initial problem of space and the physical conditions generally; in many old-established ports, densely built-up as they so often are, such conditions would alone be nearly if not absolutely prohibitive. If an adequate area, approachable by shipping, is available, the question then is whether the cost of laying it out, maintaining it and guarding it is reasonably likely to be justified by greater or swifter cargo-handling. Under this head, something depends upon the efficiency or otherwise of the existing Customs system and bonding arrangements. In the United Kingdom, one fact stands out very clearly; over the last 200 years, a vast overseas trade has been developed; and it has been built up on the seaports as we know them in association with the Customs and

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bonding system with which we are familiar. Would the country have done more business, or might it do more in the future, with free-port zones available? The matter has been considered from time to time in commercial, shipping and political circles but the general body of opinion has been that free-port zones would not bring any new benefits. Canada reached the same conclusion in 1946. The United States has gone some way in the matter and may yet go further, but the tendency is to proceed cautiously and there are many different points of view.

Ancillary Services.

In earlier chapters of the present series as well as in the companion volume, there have been many references to the multifarious activities and organisations which are normally to be met with in a seaport. It may be useful to summarise them here with a brief note as to the economic basis of each service.

An incoming vessel, approaching a port, normally requires, in the following order, assistance from coastal lightships, lighthouses, buoys and beacons, harbour lights, the pilotage service, possibly shore-based radar, the towage service and the foyboat service.

The general lighthouse authority for England and Wales, the Channel Islands, the adjacent seas and islands and Gibraltar is the Corporation of Trinity House, Deptford Strond, London. The Corporation controls some 60 lighthouses and 40 lightships. The fund for the construction, maintenance and administration of these and other seamarks is provided by means of special dues called light dues levied on shipping using the ports of the United Kingdom. The work of collection on behalf of the Corporation is done by H.M. Customs, and the accounts are submitted annually to Parliament. Vessels with cargo to or from foreign ports pay 11d. per net register ton, whilst home traders pay 6d. The maximum charge in one year is 6 voyages in the foreign trade and 10 in the home trade. Where a vessel makes some foreign voyages and some home, the maximum total annual charge is 5s. 6d. per net register ton.

There are four other statutory authorities having the style Trinity House—for example, Trinity House, Newcastle-upon-Tyne. The last-named has responsibilities in regard to certain buoys and beacons between Holy Island and Staiths. This body collects fairway dues (also through H.M. Customs) and the charge for each laden ship, coming into or going out of the ports in the district, ranges between 8d. and 3s. according to size. A vessel laden both ways pays twice; a vessel with cargo one way only pays once; and a vessel unladen both ways also pays once. Fishing vessels, smacks, boats, harbour craft and vessels forced to put back do not pay. Her Majesty's ships are also exempt.

Harbour lights are commonly provided and maintained by the Port Authority. At some places, vessels pay a small special due. based on net register, for this facility and, at others, it is merged in the general due payable for the use of the port facilities.

The pilotage service at a given port may be under the control of an independent pilotage authority or may be administered by the port authority. The financial basis of the service is a scale of charges, commonly regulated according to the draught and size of the ship, and the length of the move, payable by vessels for the pilots' services. In the United Kingdom, the underlying law of the matter is codified in the Pilotage Act 1913. The pilots operate under license awarded by the authority to satisfactory applicants after passing tests and gaining experience deemed adequate for the work they have to do. There are ports where pilotage is compulsory and others where it is not; this affects the economics of the service but probably not very significantly; even at non-compulsory ports, very few masters—except men with local knowledge commanding small ships—elect to enter unpiloted. Sunderland, for example, is a non-compulsory port.

Towage is most often carried out by firms of tugowners established in the port. The financial basis is a scale of charges regulated according to the number of tugs ordered, the size of the ship and the length of tow.

The services of foyboatmen are required to take ship's lines on arrival, departure or moving and it is their business to attend to fastening or casting off the mooring ropes at quay bollards or in buoy berths. The work is often restricted to men holding a license from the port authority and they are paid by the shipowner in accordance with a locally agreed tariff based on the size of the ship, the length and difficulty of the manœuvre and the number of stops or swings involved.

Other ancillary port services, such as cargo-handling, railway working, ship repairing, bunkering, watering and victualling have been dealt with in earlier chapters or in the companion volume.

Port Associations.

In the United Kingdom, there are two national associations which between them cover a large part of the field of port affairs. They are concerned, respectively, with administration matters and labour questions. The first is the Dock and Harbour Authorities' Association and the second is the National Association of Port Employers. Representatives of the latter body and representatives from the port workers' trade unions form the National Joint Council for the Port Industry.

The objects of the Authorities Association are:

(a) To consider all matters affecting the general interests of Dock or Harbour Undertakers or Authorities, Conservancy Authorities or Pilotage Authorities and to make recommendations thereon.

(b) To promote, further and protect the general interests of Dock or Harbour Undertakers or Authorities, Conservancy Authorities or Pilotage Authorities.

(c) To take common action on any Public Bill, proposed Departmental Order or other measure of a legislative character that may in any way affect the common interests of Members of the Association; and

(d) Generally to consult and co-operate on all matters affecting the common interests of Members of the Association and on which it may from time to time be thought desirable to take action.

The members of the Authorities' Association are port, dock or quay authorities in the British Isles and also harbour, conservancy and pilotage authorities. Associate membership may be extended to bodies or organisations having interests in common. Honorary membership may be allowed to overseas authorities within the British Empire.

The Executive Committee of the Authorities' Association consists of elected members from the port, conservancy and pilotage authorities of the British Isles, divided into 11 groups, one member representing each group, with the addition of a twelfth elected member to represent small ports. The president and the parliamentary chairman, and the chairman of the executive committee if not an elected member, are ex-officio members. The work of the Association is financed by annual subscription from the member-ports in accordance with a scale based on the gross revenue derived from dues on vessels. There are sub-committees for (1) Parliamentary and general matters; (2) Dock and factory matters; (3) Rating and valuation matters; (4) International maritime Conventions; (5) Buoyage and lighting of coasts; (6) Accounting matters and (7) Engineering. In its last annual report the executive committee recorded an ordinary membership of 83 authorities and 8 overseas honorary member-authorities. The work of the year included (1) consideration of and necessary action taken regarding seven parliamentary bills which passed into law, three private Acts and three parliamentary bills pending; (2) discussions on port affairs with the Ministry of Transport, the Ministry of Labour, the Chamber of Shipping and the British Transport Commission, and (3) consideration of matters affecting inland carriage charges on merchandise, port rates and charges, the handling of explosives and petroleum spirit in ports, fire prevention and fire fighting in ships in port, the proceedings of the Central Advisory Water Committee, the Anglo-American Council on Productivity, dock amenities, prevention of damage by pests, radio aids to marine navigation, war damage and many other aspects of the work of dock and harbour administrators.

The membership of the Port Employers' Association includes shipowning companies, stevedoring firms, port authorities, wharfingers, lighterage contractors and some others. It has a national executive committee of 25 members with standing sub-committees

Port Economics—*continued*

as follows (1) the Employers' side of the national joint council executive committee; (2) the employers' side of the national conciliation committee; (3) the port authorities' labour advisory sub-committee and (4) the technical sub-committee.

In its last annual report the executive committee gave an account of its consideration of and action upon such matters as (1) national wage claims; (2) average earnings of the workpeople; (3) the mechanisation of cargo-handling; (4) the report of a freight-handling team which had visited the U.S.A.; (5) the turn-round of shipping and the compilation of statistics relating thereto; (6) strikes, embargoes on overtime working and go-slow movements; (7) the standard of discipline in the industry; (8) overtime agreements; (9) the financing of the national dock labour scheme; (10) the functioning of appeal tribunals; (11) dock amenities; (12) the medical care of workpeople in the ports; (13) the work of the conciliation committee in settling wage claims; (14) the training and education of port workers and (15) a large number of other subjects relating to the efficient operation of the port industry.

The Association operates provincially through 8 group councils and, beyond them, through a large number of employers' associations located in the ports themselves. The work of the Association is financed by annual contributions from the employer-members based upon (1) tonnage of goods handled or (2) tonnage dues paid or (3) a capitation fee according to the workpeople's register or (4) wages paid or (5) fixed annual rates or (6) a combination of fixed rates and a levy on wages.

Pilferage.

The principal economic aspect of thieving at the docks is the considerable cost of training and maintaining dock police forces and large numbers of watchmen. The same evil has involved many dock authorities in the expense of enclosing their premises by walls and fences whilst maintaining an adequate number of controlled landward entrances. Even if everybody at the docks was completely honest, some amount of watching for other purposes, e.g. Customs requirements, fire danger and the supervision of dangerous goods, would still be necessary, but it is beyond qusetion that it is stealing which accounts for the greater part of the heavy annual expenditure upon control and detection.

Writing in the "Dock and Harbour Authority" in January of this year, Mr. Roger Charles remarked that depredations by well-organised gangs of thieves operating in the port of London formerly resulted in serious losses to merchants, shipowners and State revenue. He pointed out that the dock workers' trade unions and the National Union of Seamen take a most serious view of crime amongst their members and do their utmost to help in stamping it out. Apart from organised robbery, there exists a considerable amount of petty pilfering which has long been a nuisance and expense to dock operators. There is no doubt, however, that in London at least, the enclosing of the docks and the efficiency of the dock police force, have done much good. Before the days of enclosure, it was said that State revenue alone lost anything up to £800,000 a year; but the last annual report of the authority's chief police officer showed that the value of property stolen in the port in a year was £15,750 and that of property recovered £7,626.

To take an example from overseas, in their 75th annual report relating to the year 1951, the Melbourne Harbour Trust Commissioners remark that they have now compounded more than seven-tenths of their effective wharf area, the only legal exits being through cargo checking gates. To take goods through these gates a permit must be obtained from the delivery clerk at the shed from which the cargo is being collected. The permit specifies the nature and markings of the packages and the quantity for which the permit is authorised. The protection system also includes the padlocking of sheds, police patrols, a watchman-fireman system and the licensing of workpeople carrying out port services. By these means, cargo losses sustained by overseas shipping companies have been brought down from 14.82 pence per ton in 1947 to 4.27 pence per ton in 1951.

(to be continued)

Correspondence

To the Editor of *The Dock and Harbour Authority.*

Dear Sir,

South Wales Port Facilities

From time to time there are articles, discussions and various proposals made as to what should be done in order to give better facilities to export traffic from the West Midlands to the South Wales Ports.

It is appreciated that any development in communications should benefit the South Wales ports and I suggest more attention should be given to the services which operate on the River Severn, which give direct access to all Bristol Channel ports.

It is possible to move traffic to a particular ship in time for export closing date if some organisation is evolved.

An enterprising Shipping Company or Shipping Agent may like to give consideration to the following points:—

(1) The possibility for cargoes affecting particular ships being assembled from the Midlands at waterheads at either Stourport or Worcester.

(2) That by such an arrangement through freights are quoted from waterhead to destination, the Shipping Company accepting all costs of movement to the port.

(3) By using waterway services, overside delivery to a ship can be effected, thus avoiding quay congestion.

(4) Uneconomical expenditure in lorry running time, waiting time and turn-round can be saved by using a shorter haul with the need for fewer lorries.

(5) Goods can move safely and surely in motorised craft classed A.1. at Lloyds, and the fear of pilferage and damage in handling is at a discount.

(6) Craft can move from waterhead to the chief export ports of the Bristol Channel in 36/48 hours.

By carrying out these suggestions an efficient waterway service could be used more effectively in supplementing rail and road services to the South Wales Ports.

Docks & Inland Waterways Executive,
16, Bridge Street,
Birmingham, 1.
2nd October, 1952.

Yours faithfully,
J. E. OXLEY,
Divisional Traffic Officer,
South-Western Division.

From Sir Claude Inglis, C.I.E., B.A., M.I.C.E.

To the Editor of *The Dock and Harbour Authority.*

Dear Sir,

Silting in Estuaries

In your issue for August, 1952, you published an article by Mr. A. H. Laurie on silt control in rivers and basins by means of an air-lift. While not proposing to criticise, at this stage, his theory of silting in estuaries (a subject on which little is yet definitely known), I should be glad to learn if Mr. Laurie's patent has been applied to any of the problems he describes and, if so, with what results.

It would also be interesting to know something of the model experiments which he mentions in connection with the use of an air-lift to reduce silting in tidal basins. Some information about the subject of this model, its scales, method of tidal reproduction, and the condition of flow outside the basin, would be necessary before the results of such experiments could be judged impartially.

In the absence of such information, it would seem wise to be cautious in considering the claims made for such a novel device.

Gothic Cottage,
Wallingford, Berks.
8th September, 1952.

Yours faithfully,
C. C. INGLIS.

Seiche in Harbours

Investigation into Wave Patterns

By J. S. McNOWN* and P. DANEL†

I. Introduction.

In order to reduce the disturbances produced in a harbour by sea waves, it is essential to investigate first the characteristics of these disturbances and the manner in which they are produced. So little is known of these motions, aside from the results of model studies, that the harbour engineer is forced to complete his design without the possibility of recourse to basic principles of fluid flow. Because the wave patterns and mass oscillations in harbours are extremely complex, an understanding of the phenomenon can be obtained most directly by first studying harbours of simplified geometry. In this way theories can be developed and systematic laboratory studies can be conducted. Knowledge of the elements of these undesirable disturbances in idealised cases will greatly facilitate the solving of the far more complex problems confronting the harbour engineer.

In the hope of evaluating certain phases of this complex problem, a study has been made of harbours for which the walls are vertical, the depth constant, and the plan of the harbour geometrically simple. In this way the surface disturbances were isolated and studied as a preliminary to an investigation, yet to be made, of methods of reducing them. The present study also furnishes information which is directly useful in the design of harbours and in the control and interpretation of experiments with harbour models.

II. Theory.

Although the surface disturbances in actual harbours are far too complex for complete analysis by theoretical means, significant results can be obtained for certain idealised cases. A complete analysis of surface disturbances of small amplitude has been made for both circular and rectangular ports in which the depth of water is assumed to be constant. This analysis proved extremely useful in the conduct of the laboratory study, and provided results for a much wider range of occurrences than were tested in the laboratory. As some elements of this theory have already been presented[1], and as the remainder will be presented in a more detailed article to be published in "La Houille Blanche," only the basic assumptions and the practical significance of this analysis need be included.

In addition to the restrictions on the geometry of the port, the assumptions were also made that the effects of viscosity were negligible and that accelerations in the vertical direction were small compared to those in the horizontal direction. A clapotis, or standing wave, was assumed to form at the entrance to the harbour in conformance to occurrences observed in the laboratory study. The appropriate velocity potential was then derived and expressions for the surface configuration were obtained therefrom.

Two types of solutions were found which differed from one another both in analytical method and in their interpretation. One result, for resonant motions, included those modes of motion which can take place in closed basins and which have been studied by Rayleigh(2), Guthrie(3) and Bouasse(4). In this type of motion the entrance can be closed without altering significantly the nature of the disturbance because the velocity normal to the plane of the entrance is zero. In the second type of motion, known as non-resonant, the normal velocity at the entrance is periodic, other than zero, and forms an integral part of the internal motion. The term "resonant" is used in this instance, not in the sense that the amplitude of the motion tends to increase without limit, but rather in the sense that the characteristic motions occur for certain periods which are thus natural or resonant periods for the particular harbour geometry in question. The period of the motion within the harbour is, of course, that of the external wave, and the amplitudes of the motion inside the harbour are fixed, in accordance with the laws of motion, in such a way that the amplitude at the entrance is that of the external clapotis. Thus, as the motion commences from rest, the amplitude increases as it approaches equilibrium until both the mode and the amplitudes correspond to the external wave. Subsequently, the action of the wave adds only the small amount of energy necessary to maintain this motion within the port. Conversely, the effect of this motion on the incident wave is almost the same as it would be if a solid barrier were placed at the entrance for resonant motions.

If the plan of the harbour is circular, the profile of the surface is expressible in terms of Bessel functions. Any of the various orders of Bessel functions is a possible solution for a resonant motion. Moreover, for a given order it is theoretically possible to have any number of local maximum displacements between the centre and the wall. The displacement is given by the equation:

$$n = J_n (kr) \cos (n\theta) \cos \frac{2\pi t}{T} \qquad (1)$$

in which J_n is the Bessel function of order n, r and θ are polar co-ordinates with the origin at the centre, t is time, T is the period, and **k** is a parameter defining the transverse scale of the movement. Once the radius of the circle is known and the type of motion has been chosen, the value of **k** can be obtained from a table of Bessel functions. Then, if the depth h is known or assumed, the period can be calculated from the well known formula for waves in shallow water:

$$\frac{(2\pi)^2}{T} = gk \tanh (kh) \qquad (2)$$

Although an infinite number of possible motions exist for a circular harbour of given radius and depths, for relatively few of these is the period likely to occur in nature. For example, with a harbour radius of 300-ft. and a depth of 15-ft., the profiles of the possible resonant motions with periods in the interval between 8 and 10 seconds are shown in Fig. 1. These are compared by assigning to each the relative value of unity at the entrance. It is immediately apparent that the maximum amplitude can occur at the entrance, at the centre, or at an intermediate point. In some cases, particularly for motions corresponding to the zero order Bessel function, the amplitude within the idealised harbour is much greater than at the entrance. Furthermore, the latter amplitude is already nearly twice that of the

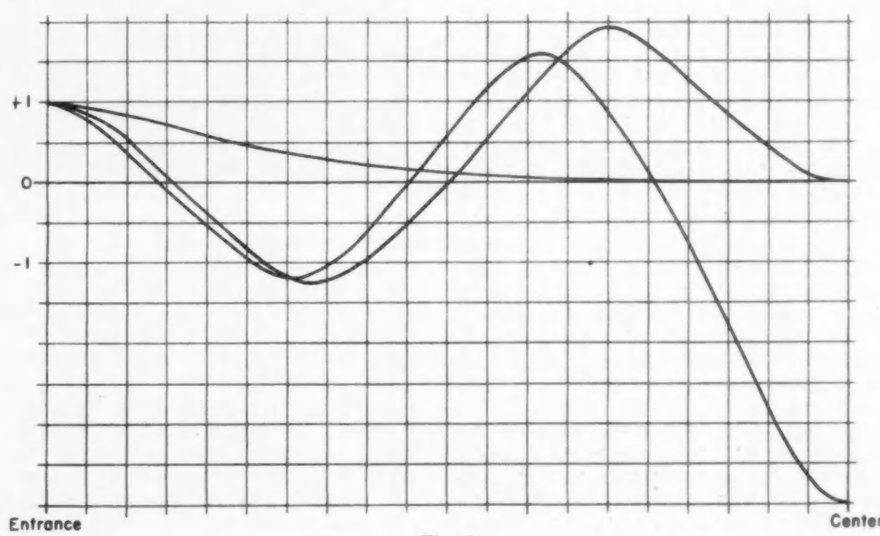


Fig. 1.

*J. S. McNown, Associate Director, Iowa Institute of Hydraulic Research, Iowa, U.S.A.

†P. Danel, Ingénieur de l'Ecole Centrale des Arts et Manufactures de Paris, Directeur du Laboratoire Dauphinois d'Hydraulique (Etablissements Neyrpic), Grenoble, France.

Seiche in Harbours—continued

approaching wave because a clapotis tends to form at the entrance.

For periods intermediate between those for the various motions illustrated in Fig. 1, the motion is non-resonant, and the corresponding analysis is more complicated, because no single mode is dominant, so that each calculation involved a summation of terms. In the summation an averaging effect takes place, so that in the transition from the profile of one resonant motion to that of another the amplitudes are, for the most part, much less than those for the resonant motions.

In a rectangular harbour of uniform depth the patterns of resonant motion are sinusoidal, being expressible in the form:

$$n = A \cos \frac{\pi mx}{a} \cos \frac{\pi my}{b} \qquad (3)$$

in which x and y are distances measured parallel to the sides of length a and b, respectively, and A is a coefficient defining the amplitude of the occurrences. For such motions the reference value k is defined by the equation:

$$\frac{(k)^2}{\pi} = \frac{(m)^2}{a} + \frac{(n)^2}{b} \qquad (4)$$

Thus integral values can be assigned for m and n, which are the number of nodal lines parallel to the x and y axes, respectively. Then, if a, b, and h are known, the corresponding period can be computed from Equation (2).

From Equation (3) it can be seen that a wave at the entrance of a rectangular port can generate a seiche within the port for which the nodal lines (or crests and troughs) are either parallel or at right angles to the incident wave if m or n is equal to zero. Also, if m and n are both integers other than zero, the standing wave pattern is rectangular with the displacement in one sub-division always out of phase with that in adjacent sub-divisions. The explanation of the apparently strange fact that a simple wave can also generate a wave pattern at right angles to itself depends on the manner in which the stimulation takes place. The incident wave does not pass through the entrance with a consequent refraction and manifold reflection. On the contrary, it provides at the entrance a periodic disturbance, which in turn produces within the harbour an oscillatory motion characteristic of the period and the harbour shape.

For the rectangular harbour, not only must the correct period exist if a given motion is to be produced, but also the location of the entrance in one of the sides must coincide closely with a region of maximum displacement, and in this the rectangle differs from the circle. In a circular harbour any possible pattern can be rotated until this second requirement is met, whereas in a rectangular harbour with the entrance at the centre of one side, for example, no resonant motion can be produced for which there is an odd number of nodal lines parallel to the direction of travel of the incident wave, because one of these lines would then pass

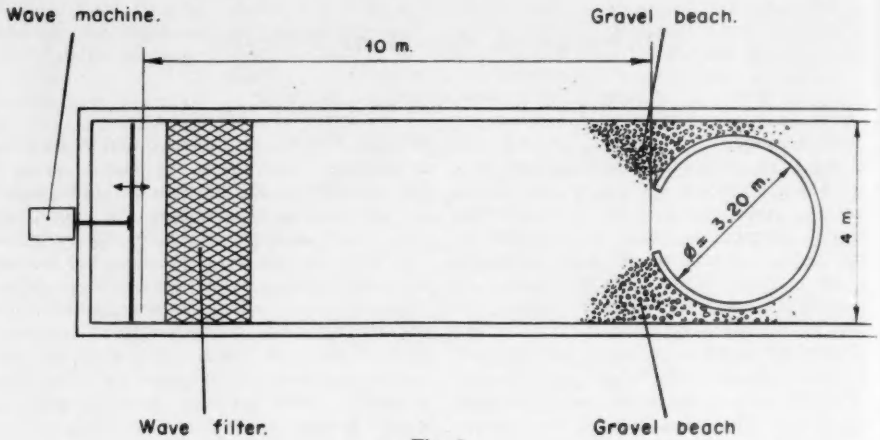


Fig. 2.

through the centre of the entrance, an impossible condition.

For motions with non-resonant periods, or for motions with resonant periods in harbours with the entrance not suitably located, an infinite series solution is necessary. Once again, varying degrees of each of the possible resonant motions combine to form a complex surface pattern. Although any particular case can be calculated, such a calculation is long, and the results give little insight into other possible motions.

In the foregoing discussions of the various types of motion possible in circular and rectangular harbours, no mention has been made of the effect of the width of the entrance, usually an important factor in the design of a harbour. For the idealised harbours in which only a negligible amount of energy is dissipated, the width of the entrance is relatively unimportant. Only if the width is very small, on the one hand, or so large, on the other, that it approaches the spacing between nodal lines, are significant effects to be expected.

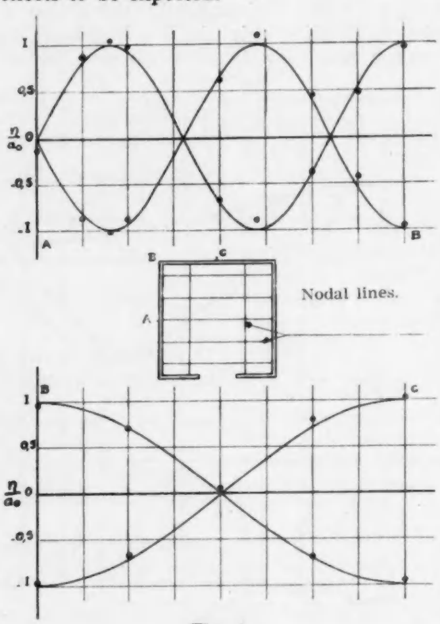


Fig. 4.

From the analysis of motions in idealized harbours, a concept of the various modes of motion which might occur and their relationship to the shape and dimensions of the harbour are obtained. Nevertheless, even for the special cases for which this analysis can be readily resolved, restrictive assumptions have been made. Justification for this analysis must therefore be sought in a comparison of representative results from theory and from the laboratory.

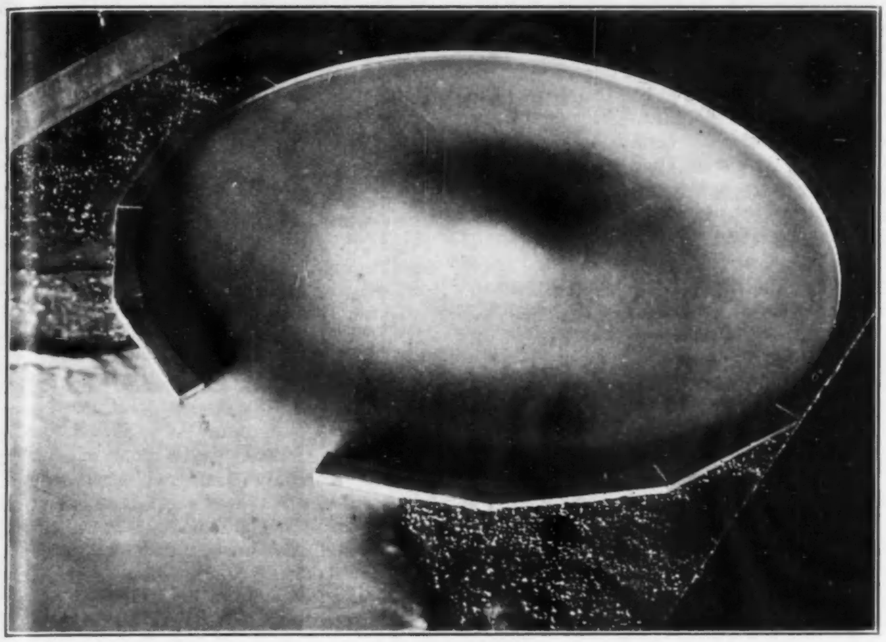
III. Experimentation.

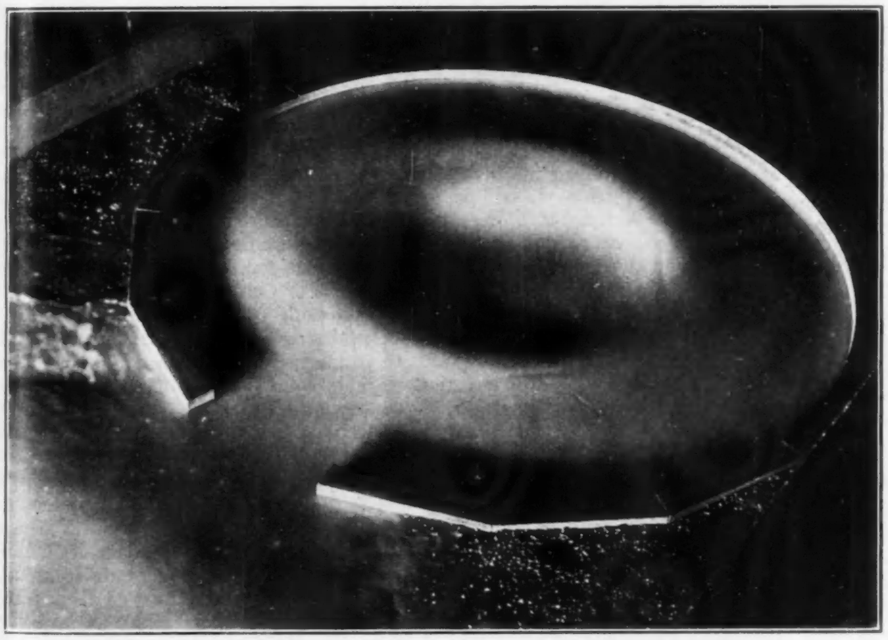
Models of both circular and square harbours were constructed in a wave flume in the Neyrpic Hydraulics Laboratory (Grenoble) and numerous experiments were conducted. The harbours were constructed of specially formed concrete blocks, and waves were produced at one end of the flume by means of a wave machine of adjustable frequency. Numerous types of motion were observed depending upon the form of the harbour and the frequency of the wave, and, for several of these, measurements of the amplitude of the surface displacement were made at various points.

The flume was 4 metres wide and the distance between the wave machine and the entrance to the harbour was approximately 10 metres (see Fig. 2). The diameter of the circular harbour and the side length of the square one were both 3.20 metres. A constant water depth of 16 cm. was maintained in the channel during the tests. In order to provide as nearly as possible a pure incident wave, harmonics, unwanted disturbances, and reflections were reduced through the action of a beach of fine gravel placed at either side of the port entrance and by the presence of wave filters made of wire mesh (5).

The period of the wave was set for each experiment by adjusting the variable-frequency motor until the elapsed time for a certain number of wave cycles, as noted on a stop watch, had been brought to the correct value. Amplitudes of the periodic motion were then measured outside the harbour, at the entrance, and at various points within the harbour by means of a modified point gauge. A double-ended needle was mounted in the vertical position

Seiche in Harbours—continued





Figs. 3 and 3a.

on a horizontal arm fastened to the movable portion of the gauge. The upper point of the needle was used for measuring the lowermost displacement and vice versa. Both points were carefully sharpened so as to reduce the unwanted effects of surface tension.

Amplitudes of the surface displacement were measured at various locations for a variety of motions in both harbour models. Perhaps the most striking of the many motions observed were those corresponding to the J_0 function. As is evident from Fig. 1, only for these motions is an amplitude at the centre other than zero to be expected for the circular harbour. Photographs of one such motion are shown in Fig. 3 for the two instants of maximum displacement (out of phase by one-half of the period). In this case there are two nodal circles for $r/R=$ 0.343 and 0.796. The amplitude at the centre is theoretically 3.33 times that at the wall (and entrance), and that of the intermediate ring with crest at $r/R=0.546$ is 1.34 times that at the wall. The corresponding measured amplitudes were found to be very nearly the same as those calculated.

Another type of motion, for the square harbour, is illustrated in Fig. 4. For this motion, as shown in the inset, there are two nodal lines normal to the line of the entrance and five parallel to it. The simple sine curves obtained in accordance with Equation (3) are plotted together with the measured values. The curves are found to correspond very well with the trends indicated by the measured points.

From measurements of such motions as those illustrated in Figs. 3 and 4, minor discrepancies of two characteristic types were found. Because the surface displacements in the experiments were relatively large (usually 15 to 30 per cent. of the depth), the profiles were somewhat distorted, particularly near the crests. Also, despite the precautions taken in producing the wave, effects of harmonics were observed; in regions where the amplitude was theoretically zero, a small variation with a frequency twice or three times that of the principal motion was frequently observed. Aside from these comparatively small discrepancies, the accord between theory and experiment was surprisingly good. The mode of motion, its correspondence with the period, and the relative magnitude of the local amplitudes were all found to be in excellent agreement.

Preliminary measurements were also made of the gradual decrease in the amplitude of the motion after the external stimulation was arrested. In one instance the wave machine was stopped, and in another the entrance was closed quickly by the insertion of an appropriately shaped plate. In both of these observations the initial motion was that shown in Fig. 3.

With the entrance open, the decrease in amplitude was more rapid than in the other case because an appreciable amount of energy left the enclosure by way of the entrance in the form of an irregular wave. The amplitude at the centre decreased to one-tenth of its original value in approximately one minute, or 50 periods.

With the entrance closed, the rate of decrease (or of energy loss) was very low, the corresponding time for the amplitude to decrease by a factor of 10 being somewhat more than 5 minutes. As the decrease was found to be approximately logarithmic, this indicated that the amplitude during a given period was about 99 per cent. of that of the preceding period. It is evident that, in the absence of significant losses due to viscosity, beaches or other energy-dissipating devices are necessary if such movements are to be prevented from occurring in a harbour.

IV. Discussion of Results.

Most important among the results of this preliminary study is the determination of the nature of possible seiche movements in harbours. The analysis, which is only referred to herein, is substantiated in all significant elements by the experiments, so that our understanding of this highly complex phenomenon is greatly increased even though only very simple harbour geometrics have been studied. Thus, a sound foundation has been supplied for future fundamental studies of various phases of harbour design.

In addition, certain facts are evident which may find immediate use in model studies of harbours or in the formulation of design criteria. Immediately apparent is that simply narrowing the entrance to a harbour will

Seiche in Harbours—continued

not prevent, and might not even diminish, the occurrence of undesirable surface disturbances within the harbour. It is essential to consider simultaneously the quantity of energy which enters and the quantity which can be dissipated within the harbour. If the latter quantity is small, a reduction in the width of the entrance would have very little effect. Because the amplitudes within the harbour can exceed, even greatly, those outside, this result is significant.

Because many widely differing modes of motion can occur, it is quite possible that a model study of a harbour can be completed without ever discovering the most dangerous types of motion, and hence without indicating the necessary protective measures to be taken. Thus the idea that a model test can be conducted for a single design period is indeed questionable. Also, because of the evident possibility of resonant motions occurring, slight changes in period may produce marked changes in the character of the motion. The accidental use of such a period in a comparison of various designs might indicate pronounced changes which result more from varying degrees of resonance or from varying patterns of motion than from a significant alteration in design.

In conclusion it is evident that the excellent concordance between results of theory and of experiment validates the analytical method, and that a significant tool is thus provided for the investigation of seiche in harbours. Furthermore, an insight is given into the possible modes of motion in harbours of idealized shape. Finally, an explanation is furnished of the interdependence of harbour width and internal energy dissipation, and of the possible importance of comparatively slight variation in the period of the incident wave.

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Book Reviews

"Civil Engineering Plant and Methods," by Rolt Hammond, A.C.G.I., A.M.I.C.E. Published by Ernest Benn, Ltd., London. 220 pp. Price 25s.

This useful contribution to Civil Engineering literature will be of undoubted interest to all those who make extensive use of mechanisation in civil engineering construction works.

The author has covered his subject comprehensively and lucidly and has illustrated his text with many photographs and a considerable number of line drawings from his own pen, which adds uniformity to the general appearance of the book.

There are ten general headings, including chapters on excavating plant, piling, cranes and lifting appliances, foundation plant and methods, concrete mixing and placing.

One chapter worthy of special mention deals with dock construction, and details are given of the work carried out at Kilindini soon after the First World War, as the methods employed, the plant used, and the problems encountered and overcome provide an outstanding example of this type of work.

The author also gives details of the underwater work and diving-bell technique which have been developed during operations on the harbour installations at Lisbon. Another subject of interest is the rebuilding of the Watier ship lock at Dunkirk, two notable characteristics of this work being the economical use of steel sheet piling and precast concrete in the design, and the ingenious inclusion of existing steel sheet piling in the new works.

Mr. Hammond then deals at some length with the question of tunnelling methods and equipment, and also gives interesting details of new welding processes. In the final chapter, which deals with the organisation of civil engineering work, a full consideration is given of the relative merits of various types of costing all of which merit careful study.

"The Port Engineer." Published quarterly at 51, Circular Garden Reach Road, Calcutta, India. Subscription Rate 10 rupees per annum, post free.

The first two numbers of this new magazine, which is published by the Calcutta Port Commissioners Engineer Officers' Association, have recently been received.

Following her attainment of the status of a self-governing Dominion of the British Commonwealth of Nations, India has entered on a new era of industrial progress. The development of her abundant resources has, in the past, been largely made possible by the skill and work of British engineers, many of whom have been of considerable eminence in their profession, whether concerned with railways, roads, irrigation and water supply, sanitation, docks and harbours or river conservancy.

Among the docks and harbours of India, Calcutta handles the largest tonnage of goods and is both a receiving and distributing centre for the whole of Upper India, Assam and parts of Central India. Moreover, since 1947, owing to partition, the pressure of work in Indian ports has greatly increased, and Calcutta has been called upon to handle a greater volume of traffic, so that adequate and efficient port facilities are more necessary than ever before. It is therefore with the object of affording a medium in which the varied engineering problems met with in the different ports of the country may be discussed and information exchanged, that "The Port Engineer" has been instituted.

The general idea of port periodicals dealing with matters of interest to a particular port is, of course, not entirely new, as most of the larger ports run a magazine. The primary object of "The Port Engineer," however, is to disseminate engineering knowledge and experience among harbour engineers, and the Port of Calcutta has many engineering features of interest, the details of which should be of value to all concerned, and especially to those engineers and others having new responsibilities. H.F.C.

"Marine Refrigeration" by R. Munton. Published by "Modern Refrigeration," Empire House, St. Martin's-le-Grand, London. Price 7s. 6d. post free.

As one of a short series of technical monographs on different aspects of refrigeration the above treatise, profusely illustrated with diagrams and tables, has been published on behalf of the Institute of Refrigeration.

This short but comprehensive work by Mr. R. Munton, B.Sc., M.Inst.R., is an exposition of the general subject which should prove of the highest value to all marine engineers and students. The Institute of Refrigeration has conceived the idea of providing these technical monographs in connection with other educational facilities for the benefit of rising technologists, and the present volume on the marine side, and two previously issued volumes on, respectively, "Cold Store Operation" and "Refrigeration Insulation," constitute an educational step of distinct value to the industry.

It is unfortunate that in the new publication there is no reference to cold storage plants at ports, as this aspect of refrigeration has hitherto received little notice, and the need for adequate technical details concerning this growing branch of the industry is becoming increasingly felt now that shipments of perishable foods have become an important feature of world trade.

"Ports of the World"—Sixth edition, published by the Shipping World, Ltd., Effingham House, Arundel Street, London. 1420 pp., price 80s. net, post free.

In the new edition all sections have been revised and expanded, and more particularly those dealing with North America, Europe and the United Kingdom. Many new ports which are being increasingly used by shipping are now included for the first time, and a number of smaller ports have been added to the European section. The guide to liner services has also been enlarged.

During the past year, some 200 private firms in the ship agency, shipbroking and merchant fields, have been appointed as Correspondents to a new International Exchange of Port Information. The full and accurate surveys of port conditions and charges made by these companies and compiled for "Ports of the World" are now reflected in the many improvements to be found in this edition.

Seawalls and Breakwaters

Lessons to be Learned from Failures*

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Introduction

Since the days of the Phoenicians and Egyptians, men have struggled to build harbour works capable of standing against the forces of the sea. Although the remains of Roman works have endured to the modern era, little progress in design was made until the early part of the last century. Modern developments have led to a better knowledge of wave pressures, but the principal source of guidance is still to be found by studying the causes underlying the disasters of the past.

This paper includes a brief outline of the principal structural types which have been built with varying degrees of success, a description of the results of certain model tests on a rubble mould breakwater, and a resumé of some of the most important lessons learned from the many failures which have occurred.

Sea Walls

General.

A sea wall is a shoreline structure built for protecting and stabilizing the shore against erosion resulting from wave action. The design of sea walls is not susceptible to the degree of exactness which has been reached by the science of engineering in many other fields. The principle cause for this is the wide range in magnitude of the applied forces and the difficulties encountered in attempting to evaluate them. Since most sea walls are filled on the shoreside to a level approximating that of the top of the wall, resistance to wave force is provided by the mass of the wall and by the passive resistance of the backfill.

Frequently the sea wall occupies such a position with respect to the high and low waterline that a wide expanse of beach and shallow water breaks the primary attacking waves at a distance seaward of the wall, in a succession of progressive steps. In such a case the attacking forces are due to breaking waves of greatly reduced height or to the onrush of water from broken waves. For locations with high tidal variations, sea walls are subject to a wide range in magnitude of the wave forces. At a certain tide stage, the forces may be those due in reflecting unbroken waves, whereas in other tide stages the full effect of breaking waves must be resisted.

These two types of wave action have long been recognized qualitatively. The theoretical basis for computing pressure due to reflecting unbroken waves has been developed by Sainflou (1928) and verified by several investigators. The existence of the second type of wave pressure, namely that produced by breaking waves, has become established as a result of several years of experimentation in wave pressure measurements by French and Italian investigators (De Rouville, Besson, and Petry, 1938). So far no theoretical method has been developed and accepted for computing pressures from breaking waves although Minikin (1950) has translated the model test work of Bagnold (1938-39) into a workable formula.

For a sea wall project of sufficient magnitude, a model test is the most reliable and expeditious means of determining definite information concerning the behaviour of the proposed design, subject to the attack of various assumed conditions of exposure. The prototype must be reproduced accurately in the model to achieve valid results.

As a consideration, second only to effectiveness and stability, the character of the property to be protected—whether industrial, residential, or recreational—should influence the selection of the type of wall and the architectural treatment of it.

*Paper presented at First Annual Conference of Coastal Engineering held at Long Beach, California, 1950. Reproduced by kind permission.

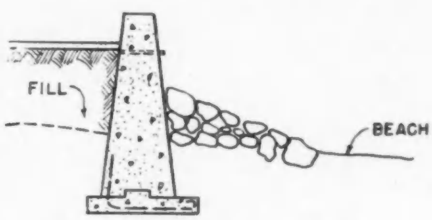


Fig. 1
Seawall -- vertical face.

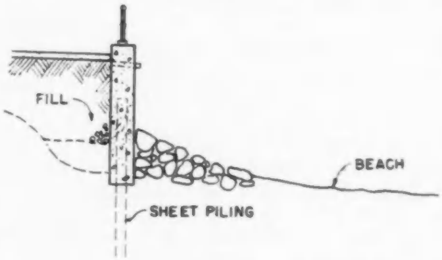


Fig. 2
Seawall -- vertical face.

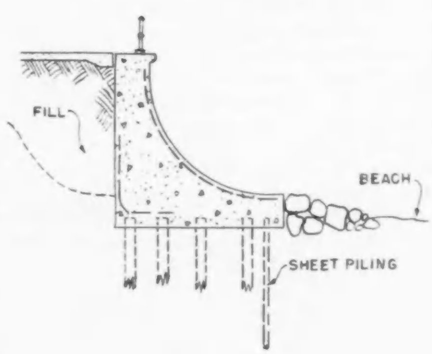


Fig. 3
Seawall -- curved face.

Types of Sea Walls.

The topography of the site, extreme tide range, wave characteristics, and foundation conditions will generally determine the type of structure to be built. Fig. 1 illustrates a version of the gravity section type of sea wall. Walls of this type have been built to heights of 50-ft., with their bases extending to a distance of 30-ft. below extreme high water level. Early gravity section walls were of dry masonry construction. These were followed in succession by cut-stone or concrete blocks dowelled or keyed together. Still later, cut-stone facings set dry, or in mortar, backed with rubble concrete, or concrete, were tried and found to be a definite improvement. Modern practice is to make the structure as monolithic as possible, eliminating all openings, cracks, and irregularities in the facing.

Fig. 2 represents a minimum construction where poorer foundation conditions exist or where erosion of sand beneath the wall is likely. The sheet pile protection has a dual purpose, namely (1) prevention of erosion and (2) support of upper cantilever wall with continuity of bending strength. This wall is suitable for mild wave exposure. It is materially strengthened against vibration and settlement of the backfill by placing reinforcing steel in the paving slab adjacent to the wall and anchoring the slab to the wall.

The wall in Fig. 3 has a curved face. It is founded on piles as required by foundation conditions, and protected against erosion at the toe by sheet piles and rip-rap cover. This wall is suitable for locations having wide beaches with a relatively flat slope of the foreshore. It is effective under moderately severe wave action. In the design of curved face sea walls, the most satisfactory shape seems to be one where the wave path is turned upward at the beach surface and outward, just below the top of the wall. Experience has indicated that the curved face is not effective in turning waves whose height is sufficient to overtop the wall.

Fig. 4 is an example of a stepped-face sea wall supported on piles and protected at the toe by sheet piling and rip-rap. This wall can be of relatively light construction and is suitable for moderate wave exposure. The stepped-face wall avoids the excessive shock pressures from wave action by forming eddies and air pockets which act as cushions to dissipate the wave energy in a series of successive stages.

The sea wall in Fig. 5 is an example of a combination where the waves are dissipated to some extent on the set of inclined steps, and any higher wave motion is turned upward and outward by the curved face of the upper portion. This type is particularly suited to locations where the foreshore is narrow and the wave attack moderate. It is adaptable to a wider range than either the curved or stepped-face used alone.

Seawalls and Breakwaters—continued

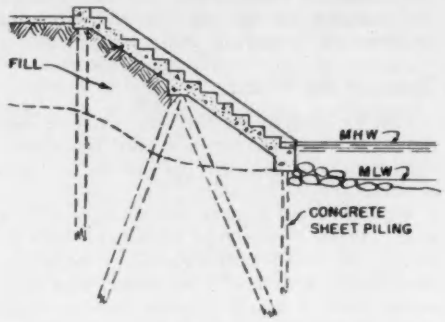


Fig. 4
Seawall -- stepped face.

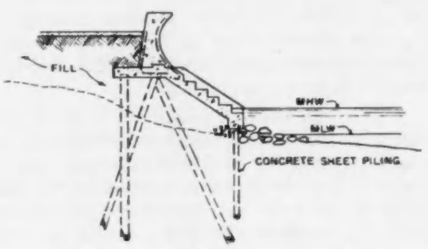


Fig. 5
Seawall -- combination.

Causes of Failure.

In the early days, when most sea walls were of the gravity type, the principal cause of failure was dislocation of the stones comprising the wall, followed by the washing out of the backfill and the resultant complete failure of the section. As sea walls have become more monolithic in construction, the principal cause of failure has been due to undermining of the toe or to the development of excessive hydrostatic pressure behind the wall. The latter produces excessive toe pressure followed eventually by settling, tipping and outward wall movement.

Failures have occurred involving modern type reinforced concrete sea walls due to lack of proper cut-off walls or rip-rap protection for the toe. Failures due to the impact of falling water behind the wall have eroded the backfill to such an extent as to leave the wall without benefit of horizontal support against the attacking wave forces. In other instances, the construction of a sea wall has altered the natural forces in such a manner as to result in the erosion of the foreshore to a depth of several feet in front of and adjacent to the wall.

Protective Measures.

Experience has demonstrated the necessity for protecting certain vital points, which are most vulnerable to wave attack. The most effective primary protection is the provision of rip-rap of adequate size and extent to prevent the back wash of receding waves from eroding the foreshore. For locations with firm bottom, this may be sufficient. For locations with soft or sandy bottom, sheet piles of adequate length are required to prevent loss of material beneath the wall itself. Adequate toe protection is the most important single precaution which may be taken to prevent overturning of the wall seaward, although proper drainage of the backfill to prevent the development of serious hydrostatic pressure differentials must not be overlooked.

Since the principle resistance to the oncoming wave force is the passive pressure of the earth backfill behind the wall, it follows that erosion in this region must be prevented. The wave attack must be broken sufficiently to prevent throwing of large quantities of water into the air to fall behind the sea wall. This is one of the principle reasons for using a stepped-face wall instead of a comparable vertical face. Although a stepped-face wall may be subject to greater wave force, as long as the passive resistance of the backfill is not reduced by erosion, the wall has adequate and lasting stability. Paving over the backfill is an effective means of preventing against erosion of the filling material. Adequate protection of the backfill against erosion is the best insurance against overturning of the wall shoreward.

After completion of a sea wall, the necessity for groynes or other additional foreshore protection should be determined by periodic checking of the foreshore profile.

Maintenance.

A sea wall is not a type of structure which may be built and left to perform its function for a long period of time without the necessity for frequent inspection and maintenance. Even after the knowledge of wave action and wall behaviour has progressed much farther than at present, there will be the need for constant vigilance to detect and correct weaknesses after severe storms, which usually occur at first in the form of erosion. The best knowledge now available cannot always predict with certainty just how a wall built at a certain location along a particular alignment will alter the natural forces. Equilibrium may be reached only after the occurrence of several typical storms and the adjustment and replenishment of the forshore protection. Sea walls built in accordance with knowledge now available, and maintained consistently, can be reasonably expected to have a long useful life.

Breakwaters

In contrast to sea walls, just discussed, which protect a shoreline with the benefit of continuous lateral support from backfill on the shore side, a breakwater is a free standing structure, located in varying depths of water, providing the primary protection for a harbour from the direct action of waves. Where these structures extend into deep water, they are subject to the full fury of the largest ocean waves occurring at the particular location.

General.

The degree of exposure at a given site is a function not only of the general geograhi-

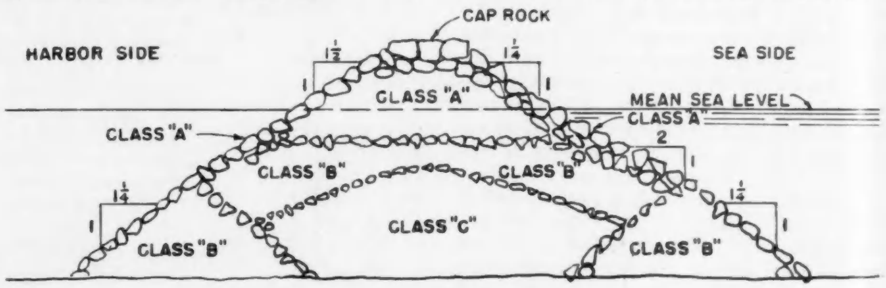


Fig. 6. Breakwater -- rubble mound.

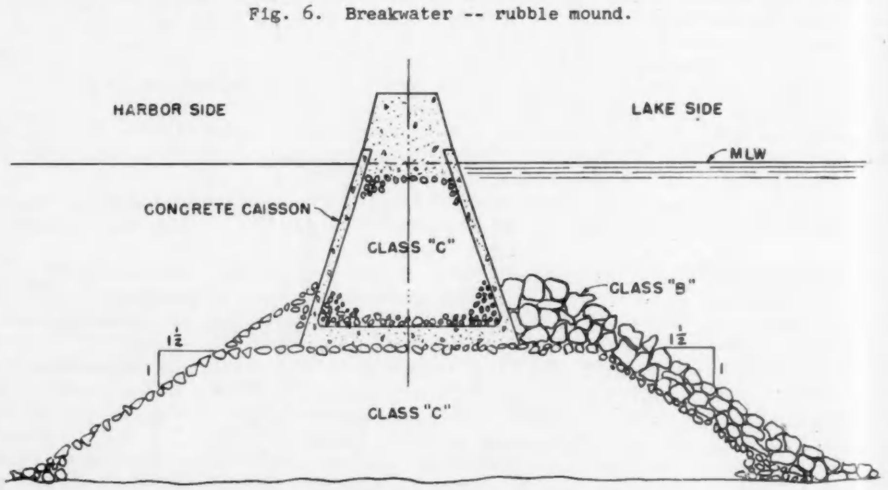


Fig. 7. Breakwater -- composite

Seawalls and Breakwaters—continued

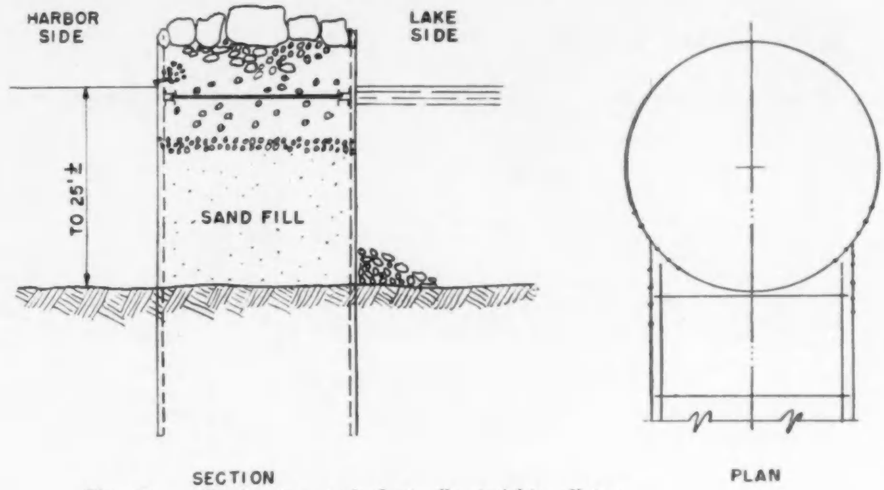


Fig. 10a. Breakwater—steel sheet pile straight wall type.

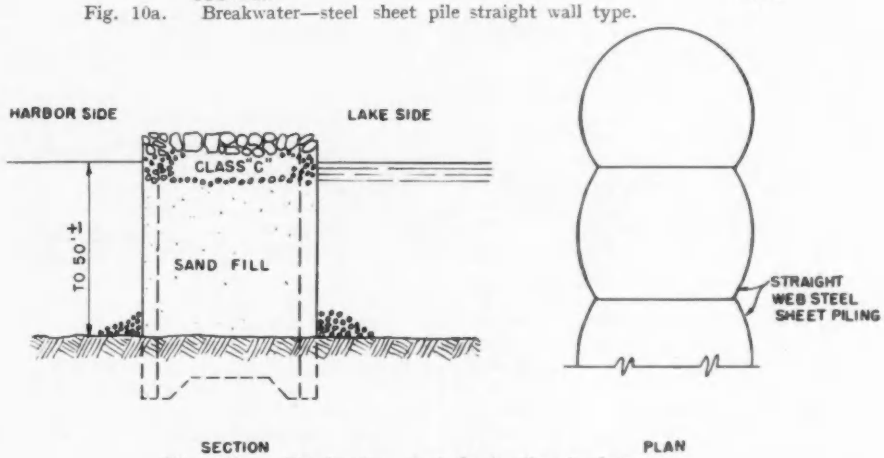


Fig. 10b. Breakwater—steel sheet pile circular type.

cal location with respect to possible wave action, but also of the local hydrography and topography. These include the water depth at the structure, the slope of the bottom, and the tidal range.

The earliest breakwaters were unformed piles of stone of a size that could be handled with the limited equipment available at the time. It soon became evident that the sea slopes were not adequate or the stones of sufficient size to resist the forces delivered by storm waves. Heavy wave action lowered the top of the mound and flattened the seaward slope. It was necessary to constantly replenish the mound until an equilibrium slope was reached. This slope was often found to vary from 1 on 5 to 1 on 10 on the seaward side within the range of the worst attack. Below this level, the slope to the bottom was often as steep as 1 on 1.

The portion of the mound above low water is extremely vulnerable to injury by storm waves in either one or both of two different actions. The first is the raising and forward transport of the stone by the incoming waves. The second is the withdrawal and lowering of the stone during the back wash or recoil.

Types of Breakwaters.

Rubble mounds have been fashioned in an almost endless variety of cross-sections. In nearly every case, the original shape has been altered by heavy storms after which reshaping and replenishment of stone has been necessary in the damaged areas. An example of a modern type of mound breakwater is shown in Fig. 6. The large mass of stone is so arranged that the smaller sizes, forming the lower central portion of the core, are protected by the larger stones forming the exterior slopes and the upper portion, the latter being most severely exposed to direct wave action. The relatively large volume of Class B stone indicated is to provide adequate stability during construction.

A mound of rubble stone is indicated where there is an abundant supply of rock available. It is particularly adapted for locations with small tidal range and in depths of water, up to perhaps 60-ft. It has the advantage that storm damage or vertical settlement due to a poor foundation site may be repaired by renewing or replacing the dislocated stone.

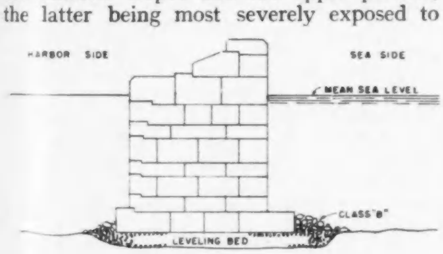


Fig. 8
Breakwater -- precast concrete or stone block -- vertical face.

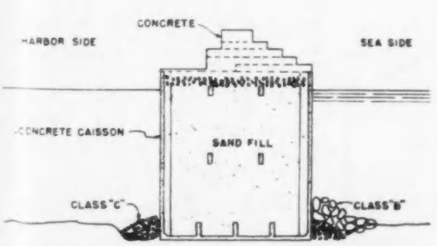


Fig. 9
Breakwater -- full caisson (modified vertifical face).

A composite type of breakwater is shown in Fig. 7. For deep water sites and at locations having large tidal variation, the quantity of stone required for full height rubble mound is not economically feasible. Such a condition gives rise to combinations of rubble bases and various types of superstructure. Here the rubble mound provides the base which accommodates itself to the irregularities of the sea bottom, and may be deposited in deep water and allowed to stand for the purpose of obtaining a large part of the total settlement before placing the superstructure. Composite breakwaters of this type may be divided into two classes, namely those with superstructures founded at low water level, and those whose superstructure extends sufficiently far below low water to avoid the breaking of storm waves and disturbance to the rubble base. The class with superstructure founded at low water, most of which were built prior to 1900, has been located at sites having a great range of tide.

Vertical-face breakwaters have been used extensively in Europe with varying degrees of success. Fig. 8 is such an example. Many arrangements of blocking have been tried. The usual practice is to set the blocks in horizontal courses with joints crossing in all directions, or suitably keyed and dowelled together. This construction has been varied, where differential settlements were expected, by trimming the blocks in inclined layers whose slope is about 70 to 75 degrees with the horizontal. Blocks weighing up to 410 tons and extending throughout the full wall thickness of 12 metres have been used in the construction of some of the more modern vertical-face walls.

A modified vertical-face breakwater is shown in Fig. 9. The lower portion is a concrete caisson-type structure, built of prefabricated units and sunk into position on a prepared sea bed. After sinking, the interior is rapidly filled to water level with sand or gravel, and covered with a protective stone blanket. After initial settlements have occurred, openings between caissons are filled with concrete and a monolithic cap

Seawalls and Breakwaters—continued

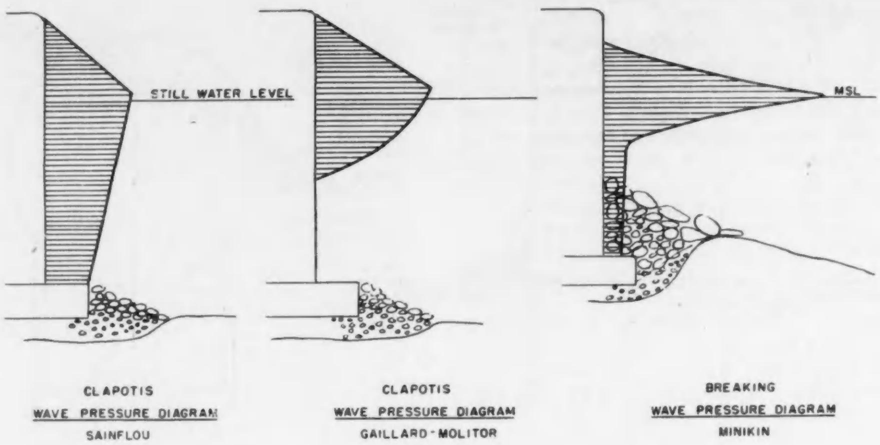


Fig. 11.

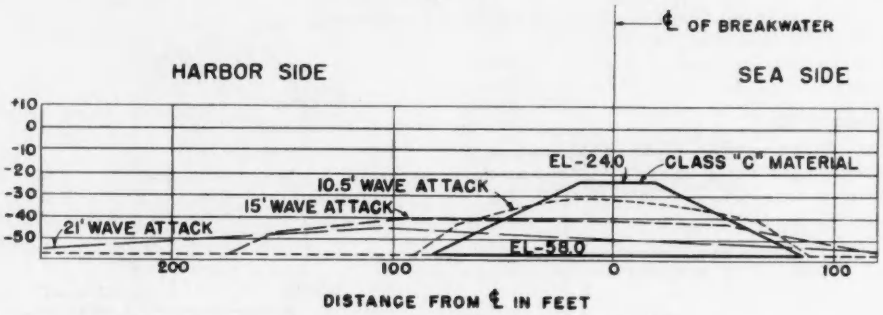


Fig. 12. Displacement of breakwater material by wave action.

structure is cast on top. The stepped upper monolith will reduce the height and rise of the waves which would otherwise occur at a vertical face, at the expense of greater wave force against the breakwater. Therefore the stepped capping may be of reduced height as compared to a vertical-face superstructure for the same degree of harbour disturbance resulting from overtopping.

The efficacy of this design has not been definitely established. Model studies to determine the total force and height of wave rise against a vertical-face breakwater, compared to one modified at the top as shown, would establish the relative merit of the respective designs.

Figs. 10a and 10b illustrate a type of steel sheet pile breakwater adapted to fresh water sites and moderate seasonal wave disturbance. Numerous examples of this construction are found in the Great Lakes. The structure is vulnerable to storm damage before filling of the cells during construction, but this can be minimized by proper sequence of building operations.

Many other types of breakwater have been proposed and tried. Among them are pneumatic, or air-bubble breakwaters, floating breakwaters of both vertical and horizontal extent, and submerged barriers. So far as is known, no breakwater installations based on these principles have proven successful in the prototype.

Wave Pressures.

Many investigations have been made to determine the magnitude of wave forces against fixed objects. At present, two general types of wave pressure are recognised, namely first that due to reflected waves and second—that due to breaking waves. Fig. 11 gives the general shape of these two types of pressure diagram. The methods of Sainflou (1928) and Molitor (1935) refer to a form of reflected waves, usually called a clapotis. The methods employed by Lira (1935) closely approximate the analytical solution of Sainflou (1928) while hydraulic model tests conducted in the University of Lausanne, reported by Cagli (1935-36), substantiate to a marked degree the validity of Sainflou's analysis. The method of Minikin (1950) refers to breaking waves and clearly shows the high intensity of pressure developed in the vicinity of mean sea level. The total wave force and overturning effect on a given breakwater are materially increased for the case of breaking waves. Further experimental effort in measuring wave pressures and translation of the results into usable form is most desirable.

Model Test of Rubble-Mound Breakwater.

The many uncertainties attending the study of wave pressure and its effect on breakwaters has led to a search for other methods of investigation. In recent years, the success of model testing in other fields has suggested the use of this tool to the problem of breakwater stability. Accordingly, the Bureau of Yards and Docks has sponsored a testing program at the Waterways Experiment Station, Vicksburg, Mississippi. The effort has been concentrated on two aspects of the breakwater problem, namely the stability of component materials during various stages of construction and after completion of a breakwater, and the relative stability of stones of varying size and density.

Stability of Materials during Construction Stages.

For the purpose of the model study, the ranges of stone weight in the various classifications were as follows:

Class A Stone

Percent of Total	Prototype Weight
75	10— 12 ton
20	3— 9 ton
5	1— 2 ton

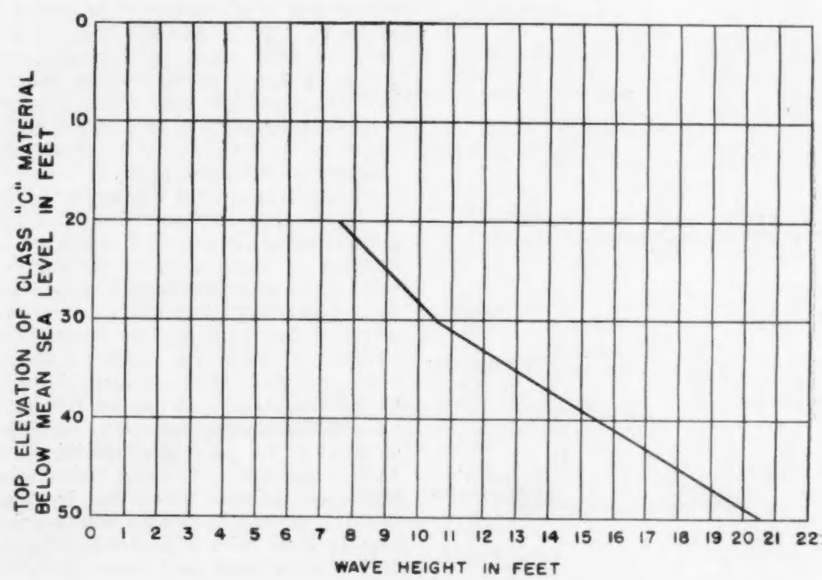


Fig. 13. Stability of class "C" material.

Seawalls and Breakwaters—continued

Class B Stone	
15	2— 4 ton
30	1— 2 ton
15	100—1000 lb.
10	50— 100 lb.
5	20— 50 lb.
5	10— 20 lb.
10	5— 10 lb.
5	1— 5 lb.
5	less than 1 lb.
Class C Material	
50	0.50—1.00 lb.
50	0.25—0.50 lb.

The first tests were performed on models of partially completed breakwater sections representative of the various stages of construction on a prototype breakwater. Each tested condition of the model was subjected to wave attack until stability of erosion and displacement had been reached. These tests were limited to the water depth prevailing at the location of the proposed prototype, namely 58-ft. Specifically, it was desired that the model should yield information of value on the following points:

1. The height to which the Class C material could be constructed without being displaced by wave action before the protective covering (Class B) was placed.
2. The advantages to be gained by placing the Class B stone concurrently with the placing of the Class C core material.
3. The amount of covering stone (Class B) necessary to protect the core material (Class C).
4. The general stability of the completed breakwater section.

Class C material—unprotected. In testing the stability of the Class C material, four different partial cross-sections representative of four stages of construction in the prototype, were used. These test sections had top elevations of —49-ft., —38-ft., —29-ft., and —24-ft., all referred to mean sea level. The model breakwater was subjected to waves of four sizes as follows:

Height	Length	L/H Ratio
7.5-ft.	210-ft.	28.0
10.5-ft.	210-ft.	20.0
15.0-ft.	270-ft.	18.0
21.0-ft.	300-ft.	14.3

Fig. 12 is typical for the tests of the C material without enrockment, with top elevation at —24-ft., and indicates the outline of the damage to the mound by waves 10.5-ft., 15.0-ft. and 21-ft. high. Fig. 13 indicates the heights to which the Class C material may be placed in 58-ft. water depth, without displacement of the material outside the design limits, for various wave heights. It will be noted that the wave heights and corresponding maximum top elevations are as follows:

Wave height	Maximum top elevation of unprotected Class C material
7 to 8-ft.	—20-ft., mean sea level
10 to 11-ft.	—30-ft.
15 to 16-ft.	—40-ft.
20 to 21-ft.	—50-ft.

Class C material with Class B stone as toe protection on one side only. Two series of tests on each of three partial breakwater sections having top elevations of 38-ft., —29-ft., and —24-ft., mean sea level, were made. One series had Class B stone protection on the harbour side only; the other series had protection on the seaward side only. A typical illustration of the results of the first series is shown on Fig. 14. It appears that there is no particular advantage in adding toe protection on the harbour side only. The waves carried the unprotected Class C material over the Class B material to such an extent that no great saving could be realized by use of this method. Fig. 15 is typical for the results of the second series, where Class B protection is provided on the seaward side only. The damage is very similar in type and extent to that of Fig. 14, indicating no advantage over placing the Class B stone on the harbour side only and, for all practical purposes, no advantage over placing the Class C material without toe protection.

Class C material with Class B stone as toe protection on both sides. Fig. 16 shows typical results for tests of partially completed sections with toe protection on both harbour and seaward slopes. For sections of lower elevation, there was considerable displacement of Class C material due to the extensive area of this material exposed to the action of the waves. The resulting scour was concave in shape, with the deposition of the displaced material greatest on the harbour slope. As the top elevations of

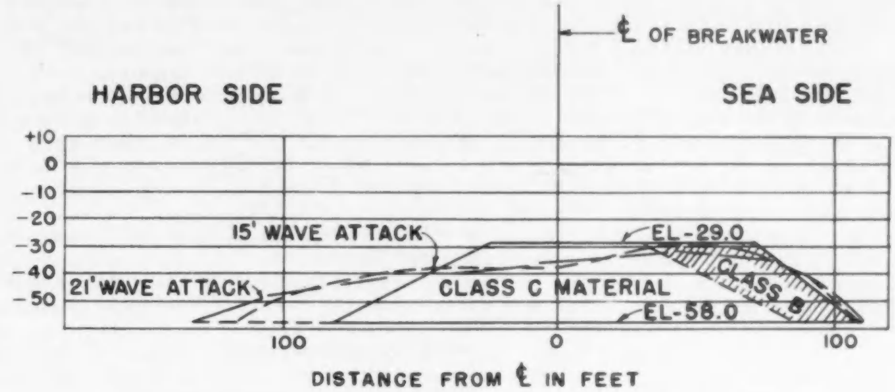


Fig. 15. Displacement of breakwater material by wave action.

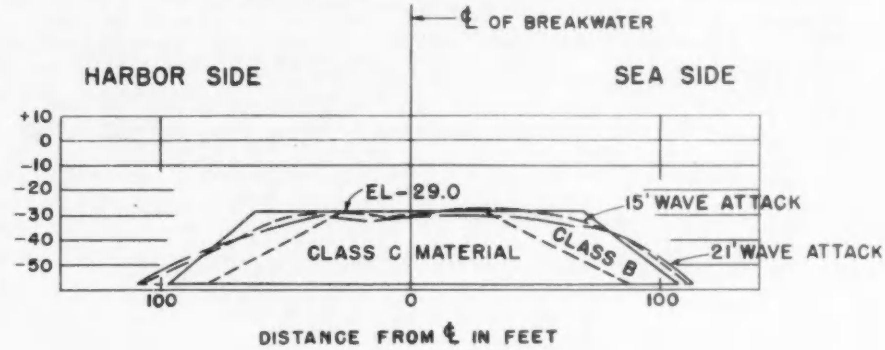


Fig. 16. Displacement of breakwater material by wave action.

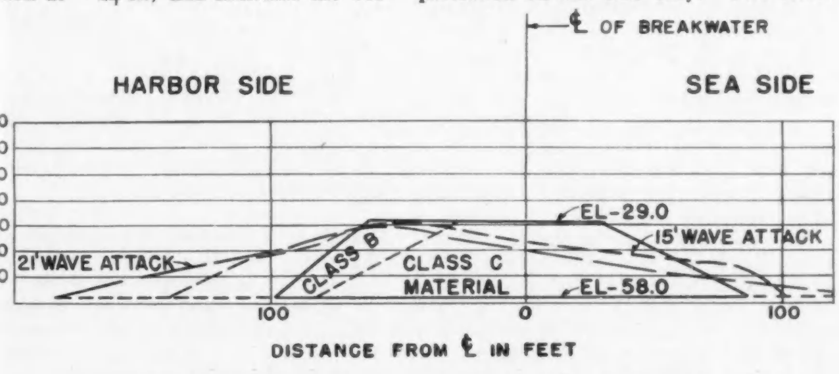


Fig. 14. Displacement of breakwater material by wave action.

Seawalls and Breakwaters—continued

the sections were raised, the exposed area of the Class C material was decreased, and the displacement of material became progressively less. As a result, there was practically no displacement of the Class C material for the tests of the section with a top elevation of —24-ft.. even during the 21.0-ft. wave attack as shown on Fig. 17.

From a study of these tests, it is concluded that the greatest degree of safety with respect to displacement of materials due to wave attack, is obtained by placing the Class B stone on both landward and seaward sides simultaneously. At lower elevations, the sections would be endangered in severe storms, but the damage would not be entirely detrimental, as the Class C material displaced would be washed over the Class B protection on the harbour slope where it would not interfere with the future placing of materials. A distinct advantage results from the fact that as the sections are raised in elevation, the area of the Class C material exposed to wave action becomes smaller, thus reducing the displacement.

Completed Class B section. The completed Class B section extending to elevation —10.0-ft. would not stand the attack of 15-ft. and 21-ft. waves. A prototype breakwater likely to sustain exposure to waves higher than 10-ft. during construction would have to be built with flatter slopes than those chosen for this breakwater.

Complete breakwater section. Fig. 18 shows the results of the tests on the complete breakwater section. Minor damage was suffered from the attack of 10-ft. waves, but the breakwater failed to maintain its design section under attack by 15 and 21-ft. waves. Thus for prototype locations where severe storms occur, the seaward slope should be flatter, with larger cap stone, or the top elevation of the Class B stone and Class C core material should be lowered to about —20-ft. and —30-ft. mean sea level, respectively, thereby increasing the mount of Class A stone.

Relative Stability of Stones of Varying Size and Density.

After conclusion of the tests just described, the Bureau of Yards and Docks has sponsored a continuation of the testing programme seeking an empirical formula for determining the weight of cap rock required to withstand design waves of various sizes, beginning with an experimental check of the accuracy of the Iribarren formula. The water depth chosen was 90-ft., with a range in size of cap rock from $4\frac{1}{2}$ to 27 tons, wave heights from 5 to 31-ft., wave periods 5 to 13 sec., and side slopes of 1 on $1\frac{1}{4}$, 1 on $1\frac{1}{2}$, 1 on 2 and 1 on 3, specific gravity of stone 2.3 to 2.8. The results of these tests so far have not been completely analyzed. The indications are that the range of conditions covering the design of rubble breakwaters is so wide that separate formulas, or perhaps separate curves for corrective coefficients will be necessary to cover the conditions of (1) no waves overtopping the mound (2) varying depths of wave overtopping.

It is realized that the information gained from this set of tests is very limited, as it applies only to one depth of water and one cross section of prototype breakwater. No quantitative information was obtained regarding the wave forces, as the tangible results appear only in terms of amounts of damage to the section tested by a particular wave. Yet these are indicative of one means of approach through a relatively new medium of controlled study.

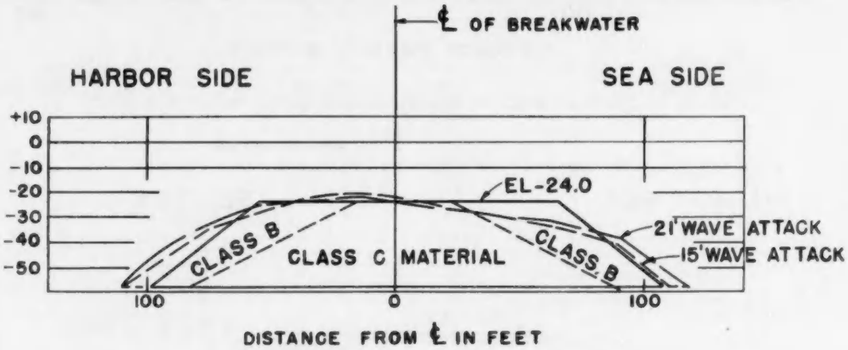


Fig. 17. Displacement of breakwater material by wave action.

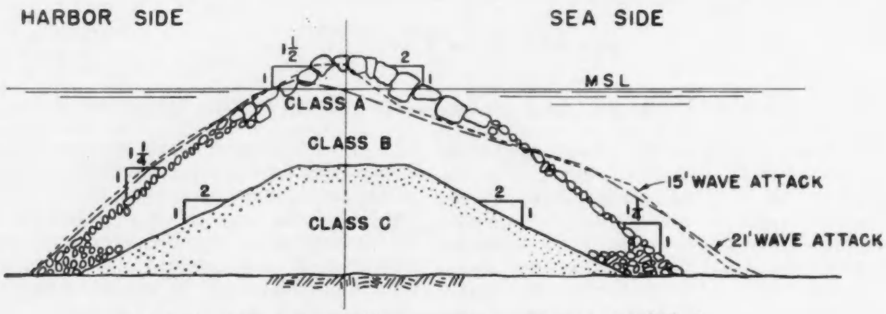


Fig. 18. Breakwater—rubble mound (model test of stability).

Basic Lessons from Experience

The lessons learned from experience provide the principal source of present knowledge with respect to breakwater behaviour. These lessons are all the more to be respected, as each one has been gained only at the expense of a total or partial failure of many actual structures.

The height and length of waves assumed for design should be sufficiently large to allow for exceptional storms as yet unknown to the locality.

Stones and blocks should be of adequate size; the smaller the stone, the flatter the sea slopes required for stability.

The destructive influence of the sea extends to considerably greater depths than was originally thought. The core protection must be of sufficient size and extent and carried far enough below water to prevent withdrawal of the smaller core material.

In breakwaters of composite construction, with rubble base and vertical wall, the top of the mound should be located sufficiently far below mean low water to prevent the breaking of the largest waves. The base of the superstructure should be protected by heavy blocks, or rubble, on the benching seaward of the breakwater.

In the case of easily erodible bottom material, a protective blanket, covering the bottom for a considerable width in front of the outer foot of the work, should be provided especially in shallower water.

Superstructures with exposed open joints are susceptible to severe damage from falling water and the pressure of trapped air.

Vertical face breakwaters should not be built in water of insufficient depth to maintain oscillatory wave motion. Those founded at the sea bed should be located in water at least twice the height of the greatest storm waves. Unless the material of the sea bottom is of a firm or rocky nature, an extensive rubble foundation is necessary to protect the sea floor from erosion for a considerable width in front of the toe.

Conclusion

The rate of progress in the science of breakwater design has been slow. Much remains to be discovered, especially in the realm of quantitative expressions for many of the combinations of primary variables. Methods of wave measurement and forecasting will do much to reduce some of the uncertainties of the past.

The science of testing by use of accurately scaled models, where the variables may be rigorously controlled singly and in groups, promises to become the most effective tool yet deveolped, not only for checking the stability and behaviour of a given design, but also for leading the way to more perfect methods of breakwater analysis.

Improved Working of U.K. Ports

Report of Ports Efficiency Committee

The first and second reports of the Ports Efficiency Committee to the Secretary of State for the Co-ordination of Transport, Fuel and Power were published last week as one Paper (H.M. Stationery Office 6d.). The Committee, which was set up last March, comprised Lord Llewellin (Chairman), Sir Ernest Murrant, Mr. F. A. Pope, Sir Douglas Ritchie, Major Roland Thornton and Mr. Tom Yates, with Mr. S. R. Walton as secretary, and their terms of reference were to "investigate the workings of the ports of the United Kingdom and in particular the ports of London and Liverpool, and to secure the co-operation of all the interests concerned, including shipping and inland transport authorities, in ensuring a quicker flow through the ports of inward and outward cargo." The Committee have now held 15 meetings and have reached a stage when they feel they can express certain views—in all cases unanimous.

At the outset, the Committee refer to the valuable work done by previous working parties and committees appointed to study various aspects of port working, in particular the Working Party on the Turn-round of Shipping in the U.K. Ports and the Working Party on Increased Mechanisation, which reported in 1948 and 1950 respectively.

They were impressed by the extent to which the recommendations of the Working Party on Turn-round have been carried out. In all their enquiries and discussions they found that a major obstable to improving the flow of goods through the ports was the difficulty in securing steel supplies for port works, and in their first report this matter was brought to the attention of the Minister and now, again, they wish to emphasise its urgent importance.

Port Operations Panels.

Early attention was given by the Committee to the possibility of working through a system of operational committees in the main ports, dealing primarily with London, where there had been in operation for several years a Port Operations Consultative Panel, which came into being following the interim report on London, made in November, 1947, by the Working Party on the Turn-round of Shipping. The work of the Panel was only partially successful owing to limitations in its constitution, but the collection, through the machinery of the committee, of daily information as to the out-turn of ocean-going ships had made possible the taking of immediate remedial action where congestion became apparent. Moreover, during times of acute congestion schemes had been put into operation relating, for example, to the allocation of labour and the supply of craft, and these had undoubtedly been effective in removing to a material extent major causes of delay. In these circumstances, the Ports Efficiency Committee took the view that this committee, or a similar one, should remain in being as part of a system which they hoped would be adopted throughout the major ports of the country.

The Committee accordingly suggested to the Port of London Authority that the existing committee should be reconstituted, and that the executive aspect of the committee, as distinct from the consultative aspect, should be emphasised. This has now been done.

The Committee then approached the chairmen of the remaining principal port authorities with a view to arranging with them the setting up of local panels on similar lines, charged with ensuring the most effective use of port resources. These panels, which would be known as "Port Operations Panels," would consist of representatives of the interests directly responsible for the turn-round of ships and the handling of cargoes and their terms of reference would be as follows:

(1) To collect and collate operating statistics and to use the information for remedying delays; and to provide the Ports Efficiency Committee with any information requested by it from time to time;

(2) To ensure the most effective use of existing physical resources of berthage and other port facilities and to secure the full utilisation of dock labour, including where necessary priority of allocation of labour to ships and cargoes;

(3) To keep the Ports Efficiency Committee fully informed of any difficulties which they may find in regard to the working of the port which cannot be solved locally and on which they consider that high-level assistance is necessary.

It is envisaged that these Panels will meet regularly, will be able to act rapidly and effectively by mutual agreement, and will keep themselves fully informed of the state of the port, the turn-round time of the shipping using it, and the rate of clearance of goods through it.

Considerable progress has been made in the setting up of Port Operations Panels, the present position being as follows:

(1) Panels set up or existing committees reconstituted with revised terms of reference: London, Liverpool, Manchester, Sunderland, Dundee, Leith, Hull, Grimsby and Immingham, Newport, Cardiff, Barry, Port Talbot, Swansea, Middlesbrough and Hartlepools.

(2) Establishment of Panel deferred: Glasgow.

(3) Local arrangements accepted by the Committee as making the establishment of Panels unnecessary at present: Southampton, Tyne and Bristol.

Central Port Users' Committee.

As a result of discussions between the Federation of British Industries, the Association of British Chambers of Commerce, the National Union of Manufacturers, the Chamber of Shipping of the United Kingdom, and the Liverpool Steam Ship Owners' Association, a central Port Users' Committee has been formed consisting of the presidents of the first four bodies and the chairman of the Liverpool Association. The Committee has the object of investigating the factors which cause delay to shipping and to exports and imports and promoting practical steps to correct such delays. It has proceeded with the formation of a system of Port Users' Committees at individual ports, corresponding to those at which Port Operations Panels are being set up.

"The parts which these two sets of committees can play in improving turn-round are clearly complementary, one approaching the problem from the point of view of the port operator, and the other from that of the customer."

Changing Factors in Port Conditions.

Dealing with the several factors which ought not to be overlooked in comparing the present average turn-round of ships in port with the corresponding pre-war experience, the report mentions the following:

(1) The capacity destroyed in the concentrated bombing of our major ports is still far from being completely restored.

(2) Much of our trade is now being carried in larger and deeper-draught ships, and this has restricted to some extent the number of ports and, more important, the number of berths at the main ports, on which it must be centred.

(3) Ships carrying export cargoes are as a general rule being more fully loaded.

(4) Exports have increased greatly in volume, and the extra handling they require, both because of their general cargo nature and because it takes longer to stow than to discharge, tends to lengthen the time of occupation of berths.

(5) Certain exports require much greater supervision by Customs owing to the operation of export licensing. Before the war there was virtually no checking of exports except for dutiable goods claiming drawback.

(6) The general "seller's market" conditions of world trade during recent years have destroyed much of the flexibility which enabled the arrival of imports to be spread and stocks to be run down, and the effects on ports of this loss of flexibility are accentuated by the bulk buying and bulk selling arrangements that still remain as an inheritance from the war.

(7) There is a growing use of road transport, often at docks originally built on the basis of rail feeder services, with the consequent receipt of exports or distribution of imports in smaller units.

"Changes such as these," the report states, "make the task of our ports more difficult, and in our view port authorities have tackled them creditably despite the various restrictions imposed by post-war shortages. Superimposed on such long-term factors

Improved Working of U.K. Ports—continued

there can be considerable short-term variations in the conditions under which ports operate."

Improvement in Port Working.

" It is apparent that a definite improvement has taken place in port working during the last four or five months. This is due to a number of cases, but by no means all of them can be expected to continue, and it would be dangerous to regard the present position with any complacency. On the contrary, it is safe to predict that certain of the causes of the difficulties and delays that were giving so much anxiety some months ago will recur, probably next winter, and the whole question of port operation should therefore continue to be treated with the same urgency with which it was regarded at the time the Ports Efficiency Committee were constituted."

Continuing, the report states that, broadly speaking, the causes which have contributed to the improvement in port working during recent months are:

(a) There has been an absence of major industrial disputes in the ports.
(b) The easing of pressure at a number of ports, whether because of falling off in traffic or other causes, has reduced the strain on facilities and labour and made it possible for men to be regularly engaged for work to which they were best suited. As a result there has been an improved output per gang hour.
(c) The weather was consistently good in the first half of the year.
(d) There has been an improvement in the use of lighters in London.
(e) The installation of two new grain elevators in London has speeded up the average hourly rate of discharge.
(f) Discharge of sugar has been speeded up, mainly because of an increase in the proportion of bulk cargoes which can be handled much more quickly than bagged sugar.
(g) Rail and road transport have been in better supply.

While each of these factors has had only a limited effect taken by itself, they have to be evaluated in the light of the strained conditions under which ports had to work.

The Steel Position.

The Committee express strongly their opinion that until the major ports are able to build up a margin of capacity they will be liable to periods of serious and costly congestion. In nearly every case reconstruction work that would make a direct contribution to reducing port delays cannot be put in hand, or sometimes even when started is at a standstill, for lack of steel. The amounts of steel concerned seem very small compared with the saving in national resources, especially in ship time, that they would make possible, and the Committee consider that more steel should be made available for those projects which can be related to a definite improvement in port capacity. There is still a substantial amount of bomb damage, particularly at London and Liverpool, that has not been repaired seven years after the end of the war, and compared with pre-war, a greater movement of goods through the ports is having to be handled with fewer facilities.

The Committee recommend the provision of a small amount of steel which would enable a number of berths at London and Liverpool to be brought back into full operation. The schemes listed in their first report are confined to these two major ports, and consist only of the provision of replacement of transit shed accommodation. By no means do they exhaust the directions in which the use of steel, in small quantites on austerity types of construction, would have a marked effect on port capacity. The total amount of steel required over the next three years for the completion of a number of schemes listed would be only about 8,000 tons.

Slow Discharge of Grain.

The most serious form of congestion at present affects the discharge of wheat and coarse grain. A substantial contribution to the easing of the problem would be made by an increase in milling capacity at the ports, and the Committee list four schemes which, they state, besides raising port grain storage capacity by some 60,000 tons, would provide an increase in present milling capacity of over 400,000 tons of wheat per annum. All but one of the schemes constitute restoration of war damage, and the total outstanding steel requirements for the four schemes is only 2900 tons. The schemes are:—

(1) Rebuilding of three mills in London for Messrs. Ranks and Spillers.
(2) Rebuilding of mill for Hovis, Ltd., in Manchester.
(3) Rebuilding of two mills in Hull for Messrs. Ranks and Spillers.
(4) Construction of new mill for Messrs. Ranks in the Western Harbour at Leith, for which deep-water quays were completed two years ago at a total cost of about a million pounds and are still unused.

Diversion of Trade.

As regards diversion of trade, the report states that " We have had brought to our attention the argument that the congestion at certain ports could be relieved by making use of other ports whose facilities are not being used to capacity. Within the terms of reference laid down for us we have not felt ourselves called upon to go into this question in detail. In the last resort the amount of trade passing through a particular port is dictated neither by the port authority nor by the shipowner, both of whom are, in this respect, the servants of the trading interest. We do not consider that there is evidence of a reluctance among shipowners generally to make calls at ports where they can have a reasonable expectation of receiving business and, indeed, we have evidence of cases in which calls have been instituted by liner companies at extra ports in such an expectation and the trade anticipated has not grown up. The distribution between ports of the country's exports and imports is dictated by many factors—the centres of production and consumption, the inland transport network, the situation of the principal markets, and so forth. In our view, the use made of ports should follow the pattern of trade rather than seek to influence it, and we have therefore confined our attention to the problems involved in improving the flow of goods through the channels which they seek to follow."

Mechanisation.

The Committee consider that mechanisation is dependent on the experience of employers and even more on the appreciation by employees that, although mechanisation schemes may in isolation involve redundancy, mechanisation as a whole is ultimately not only to their own advantage but also to the advantage of the whole country. Whereas a large amount of mechanisation has taken place in industrial establishments generally, it has been disappointingly slow at the ports. " If this country is to maintain its reputation for efficiency, it is essential that all concerned should strive to ensure that the most modern methods are used in the handling of ships' cargoes."

The Committee also point out that there is a general need for statistics of shipping turn-round and cargo handling, and they are glad to report that substantial progress has now been made by the various interests concerned, and that forms of return are being devised which will show trends in shipping turn-round time and in cargo handling at each major port.

Lighterage, Road and Rail Facilities.

Lighterage is a problem which mainly affects London, where approximately 60 per cent. of the traffic is handled by lighters. There has been an increase in lighterage capacity and in the size of the lighterage labour force, but it is nevertheless clear that, unlike the position in the other sectors of labour, there is still a shortage of men to meet peak demands in the lighterage sector. It is therefore essential, particularly at times when there is a surplus of dock labour remaining unallocated, that arrangements should be made to provide for a ready transfer of men from the other sectors should there be a shortage of unlicensed lighterage labour.

With regard to rail and road facilities the supply is now adequate except for occasional shortages at peak periods. Rail and road access and reception are also regarded as generally satisfactory, and the Committee state that their attention has been drawn to a number of proposals for improvement at Manchester Ship Canal, Middlesbrough, Glasgow and Tilbury.

Restoration Work on Bristol Granaries

Efficacy of New Process

(Specially Contributed)

One of the most serious problems confronting port engineers today is the deterioration in the buildings under their charge. With the virtual absence of maintenance work during the war years and since, many port buildings in this country now present a somewhat woeful and dilapidated appearance.

In the case of reinforced concrete structures, this deterioration, if neglected too long, can lead to most serious results through erosion of the concrete skin. In any dense concrete mix (particularly in structures built during or before the first quarter of this century) it is almost inevitable that surface cracks will appear after a time and, on large unbroken areas of walling, it is equally inevitable that there will be penetration of water into these cracks, aided by capillary attraction of the concrete itself. It then needs only a few sharp frosts to loosen the concrete surface, leading ultimately to spalling, and exposure of the steel reinforcement, The spalling of a few square feet of concrete sets up new cracks in the surrounding area and, in due course, leads to further extension of the damage.

If no action is taken at this stage, severe corrosion of the steel is rapid. Normally, it is the smaller diameter steel links which are exposed first but, with repeated spalling which eats deeper and deeper into the concrete, even the main reinforcing bars can soon be uncovered and exposed to the elements. Remedial work, at this stage, becomes a major operation and also a very expensive one.

Spalling by natural causes has been aggravated by enemy bombing to which, unfortunately, most of our ports were subjected. Bomb splinters have caused deep pockmarking and erosion of the damaged parts has spread to the areas of the concrete surrounding them.

Reparation by the traditional method of applying by hand a new cement and sand rendering has some serious drawbacks. There is, first, the question of adhesion. To create a mechanical key between the new and the old work, it is necessary to hack the whole of the surface. This, in itself, is an expensive item. Secondly, there is the almost insuperable problem of obtaining sufficient skilled plastering labour in these days when the emphasis is on house construction. Thirdly, to carry out the work by traditional practice necessitates the erection of independent scaffolding, which, in dock areas, creates a special problem on account of the roads, railway lines and crane lines adjacent to the buildings.

Assuming, however, that all these difficulties can be overcome, newly-applied rendering is still subject to the same risk of erosion as was the original concrete structure, plus the added risk of a possible breakdown in the key.

Obviously, some new method of approach must be made towards the solution of this problem. A possible answer has been found by employing the technique of aerated — concrete application. Aerated concrete, in itself, is not subject to hair-cracking to the same degree as dense vibrated concrete. Even if, in the passage of time, minute surface hair cracks should appear, it is unlikely that there will be any appreciable penetration of moisture. When cracks appear in a smooth concrete surface, water naturally gravitates towards them, but on a textured surface, water tends to fall from nib to nib of the texture without penetrating into the hollows. Any penetration of moisture through hair cracks is very slight due to the greatly reduced capillary attraction of aerated concrete.

From the point of view of subsequent upkeep cost, aerated concrete has much to commend it. Even if after some years superficial erosion does take place, the surface can be restored and given a new lease of life, by applying a further sprayed coat about ¼-in. thick, without the necessity of providing any artificial key. On dense concrete renderings, cracks have to be cut out back to the original surface and made good by hand.

Fig. 1. Illustration of section of building before commencement of work.

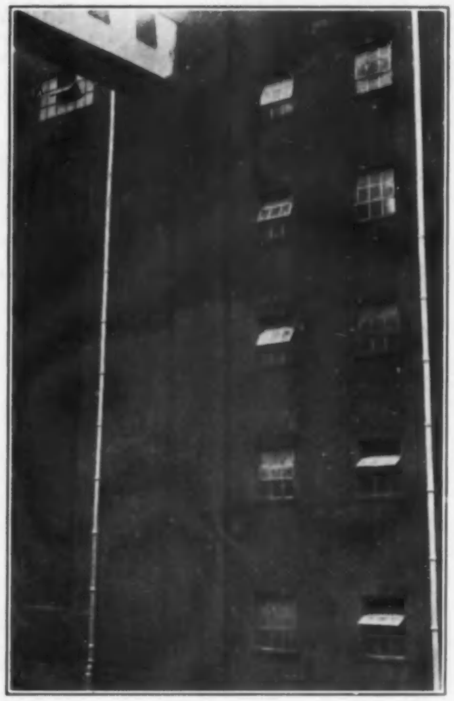


Fig. 2. View of a section showing finished work.

Messrs. Aerocem Limited, of 71, Lots Road, London, S.W.19 developed, several years ago, a special technique for the application by spray, of aerated concrete and designed machinery to enable this to be done. Apart from its use in this country, their technique has been employed extensively abroad in many phases of building construction.

At the Avonmouth Docks of the Port of Bristol Authority, where there had been extensive erosion on some of the granaries, the Engineer-in-Chief (Mr. N. A. Metheson) decided to test the efficiency of an aerated concrete application. A test panel was treated in an area particularly exposed to the elements. The possibilities of the treatment appeared such to warrant a large scale trial and a contract was placed by the Port of Bristol Authority for the complete cladding of Nos. 3 and 4 Granaries. The work was entrusted to Messrs. Clark and Fenn Ltd., 16, Old Town, London, S.W.4, who operate as contractors under licence to Messrs. Aerocem Limited.

The granaries are about 100 feet high and the area of surface to be treated is 22,500 square yards. Access for the work was a difficult problem as both buildings had roads and railways on all sides, and the narrow runways behind the roof parapets were inadequate to carry hanging stagings. It was decided that all the work should be done from cradles. The height of the buildings necessitated a complete re-disposition of the mixing and spraying machinery from the methods normally employed on buildings of a lesser height. By a very ingenious idea

Restoration Work on Bristol Granaries—continued

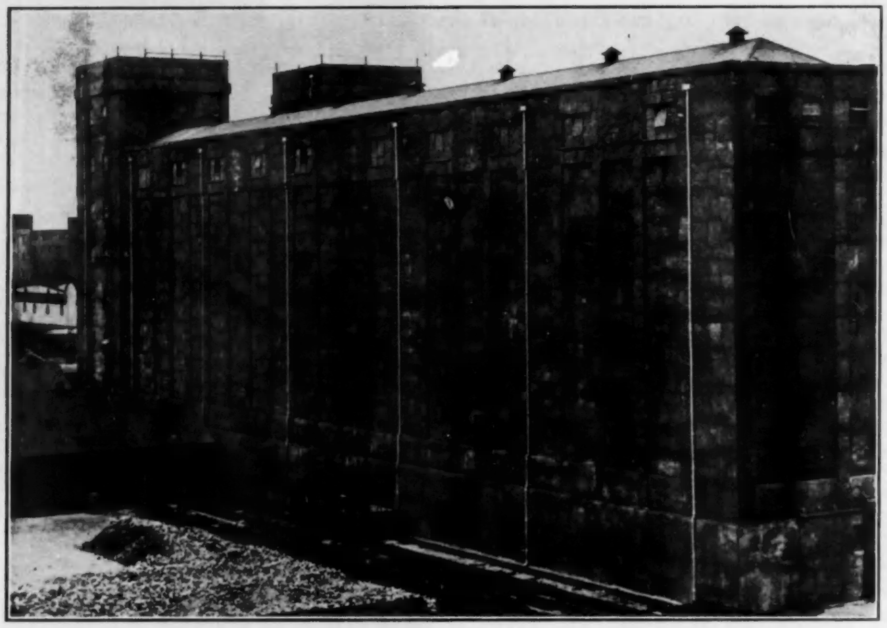


Fig. 3. General view of completed work on one of the granaries.

developed during progress of the job, it was made possible for each spraying operative to regulate personally the pressure according to his own height from the ground.

The contract provided that the whole of the surfaces were to be brushed down and all loose and flaking materials removed. Where the concrete had spalled, the areas were made good by filling in with aerated concrete, which was lightly floated over by hand to an even surface, but without consolidating its cellular structure. As no risk could possibly be taken of a failure due to lack of adhesion, the whole of the surface was then sprayed with a key-coat of aerated concrete in which was incorporated Cemprover No. 4, a product of the Cement Marketing Co. Ltd. Further layers of aerated concrete were then sprayed on to a total thickness of ½-in.

The illustrations show an area from which the concrete had spalled, photographed before any making good had been done, and the same area after completion of the Aerocem treatment.

Messrs. Clark and Fenn Limited have developed also a new process for the treatment of corrugated metal sheeting for roofs. Maintenance of these roofs is a problem that port engineers will have continually before them until such time as new sheeting can be readily obtained. The process is a combination of aerated concrete and bitumen derivatives and the principle behind it is threefold:

1. To repair any small holes in sheets that are, otherwise, reasonably serviceable.
2. To seal the surface against rain penetration with a very heavy fibrated bituminous emulsion.
3. To protect the emulsion treatment against the ravages of the elements by a sealing coat of aerated concrete, which itself contains further bitumen.

This process has already been used on warehouse roofs in the London Area. While more expensive initially than a traditional painting specification, it has a far longer life. Renovation of the surface, in due course, necessitates only a further sprayed application of aerated bituminous concrete.

Manufacturers' Announcements

New Lighting System at Shellhaven

Oil tankers from all parts of the world, and barges from the waterways of Great Britain, docking at the Shell Company's new Shellhaven Oil Refinery for refuelling, are receiving a rapid and more efficient service as a result of new fluorescent jetty lighting supplied by The British Thomson-Houston Co., Ltd., Aldwych, London, and installed by Shell engineers.

This is believed to be the first fluorescent lighting installation of its kind, and is part of a scheme to provide better working conditions and maximum production efficiency in the oil refineries of the United Kingdom.

General night view of the new fluorescent jetty light at Shellhaven taken from a ship coming in to refuel.

Daylight view of the Mazda five-lamp 5-ft., 80-watt industrial flameproof fittings used to light the jetty at Shellhaven.

Already Mazda lighting is operating in the Grangemouth and Thames-Haven Refineries, as well as at Shellhaven, and a scheme is also planned for the new Isle of Grain refinery which is now nearing completion.

At Shellhaven, eleven Mazda five-lamp 5-ft. 80-watt industrial flameproof reflector fittings, on specially constructed frames for multi-angle direction, have been mounted on Stanton columns along three jetties of the oil wharves. Lighting intensity is in the region of 17 lumens per sq. ft.

The tank farm is illuminated by 1,500-watt long-throw projection lamps and 400-watt mercury vapour fittings operated from the pump houses.

Many obstacles had to be surmounted in planning the lighting scheme, including the corrosion of fittings by salt-spray. The greatest difficulty, however, was to provide evenness of light over the jetties while at the same time staggering the lanterns so as to avoid the numerous bollards which are placed at irregular intervals. By careful planning and the use of specially designed equipment, these difficulties were overcome and officials, dockers and seamen alike have expressed their complete approval and satisfaction with the lighting.

U.S. Approval of British-Made Pressure Operated Fire Extinguisher

Negotiations over the last five years have resulted in the acceptance and approval in the United States of a pressure-operated fire extinguisher manufactured by Nu-Swift Ltd. This is the first foreign-made fire extinguisher ever approved for use in the United States.

The approval of this extinguisher on behalf of the Associated Factory Mutual Fire Insurance Companies opens up a considerable field for export to the dollar countries

Manufacturers' Announcements—continued

Fork Trucks and Pallets

Demonstrated at Materials Handling Convention

The relative merits of different types of fork-lift trucks and pallets were reviewed in two papers presented at a recent materials handling convention sponsored by Rubery, Owen and Co., Ltd., and Conveyancer Fork Lift Trucks, Ltd.

Fork Truck Design

Mr. C. W. Sharp, Managing Director, Conveyancer Fork Trucks Ltd., discussing the design aspects on various types of fork trucks, said he favoured the 4-wheeled layout for medium and heavy duty trucks because of increased stability, especially when the load, at full height, is tilted backwards. For light duty machines and where maximum manœuvrability was required, the 3-wheeled layout with the drive and steering on a single rear wheel was by far the best, as the steering was fully effective without scrubbing in the full lock position and the simple front axle, without differential or wheel coupling, enabled the minimum turning circle to be obtained.

There was still great controversy over the relative merits of solid and pneumatic tyres, but operators in the United Kingdom now appreciated that for all but the roughest conditions, such as outside operation on soft or rough ground, the solid tyre had everything in its favour. It was standard practice in America and Canada to use solid tyres for all inside work, suitable floors being provided, but in the U.K., the poor surface of the average factory or warehouse floor had delayed its adoption. The position was now changing rapidly however, as users were finding the cost of floor laying and repairing could be recovered very quickly by speeding up handling methods.

Solid tyres offered the following advantages:

(a) Reduction in overall size of truck and turning circle with resultant saving of approximately 15 per cent. in aisle width.

(b) Increase in safety factor due to freedom from punctures and greater lateral stability, particularly when the load is at the top of the mast.

(c) Reduction in traction resistance which is particularly advantageous on electric trucks.

(d) Very substantial reduction in steering resistance.

(e) Ability to withstand the wide range of loading conditions introduced by transferring the load from one axle to the other.

Pneumatic tyres offered advantages on soft or uneven ground. With pressures of 90 lbs. per square inch they do not absorb a great deal more energy than cushion tyres.

Cushion tyres, a semi-solid type of tyre, offered a very good compromise between the solid and the pneumatic, and energy absorption curves for cushion tyres were very similar to pneumatic tyre recordings.

Petrol, diesel or battery electric fork trucks were available and each type had its particular advantages, but it appeared that the swing over to diesel in the United Kingdom had come to stay, and the ratio of fuel cost was now about 2 to 1 in favour of diesel engines. At the same time, the battery electric fork truck was much cheaper in operation and maintenance was less.

Development of Pallet Design

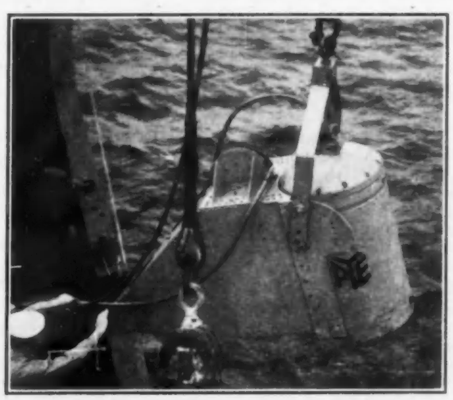
Speaking on the development and design of pallets, Mr. E. Coupland, chief engineer, Rubery, Owen and Co., Ltd., said that the potential buyer should first of all make up his mind whether pallets were really necessary. Pallets were originally designed to facilitate the use of fork trucks as a handling device, and the uses to which they had since been put should not be allowed to obscure the original idea.

Palletisation had now grown from the original simple idea to one capable of reducing handling costs at all stages, reducing the cost of stores equipment, using store space to the maximum, speeding up and cheapening stores issues and generally tightening up stores control. Finished products also could be efficiently warehoused, and the cost of crating and packing reduced and sometimes eliminated, while the loading and unloading of lorries could be greatly speeded up with the help of pallets.

The maximum advantages of palletisation could only happen when some degree of standardisation had been achieved. Efforts were already being made in this country by some trades to foster standardisation, and this movement should be encouraged.

Deep Sea Television

Since the discovery of H.M. Submarine "Affray" by an Under Water Television Camera a considerable amount of development work has taken place and the new camera chain, designed by Pye Limited working in close co-operation with the Admiralty, incorporates facilities for remote positioning and focussing. Precise optical adjustments can now be carried out from the camera control unit on board the deep diving vessel and in addition the lenses can be changed under water by remote control.



The new camera undergoing trials.

The new camera also has an increased viewing field of up to 70°.

The demonstration of deep sea television which took place on board the deep diving vessel H.M.S. "Reclaim" in Falmouth Bay a few months ago was the first public demonstration of its kind.

Two tests were carried out, one in relatively shallow water, at a depth of 10 fathoms, when close up pictures were shown of two divers on the sea bed. During the second demonstration, which took place later in the day, an uncharted wreck was discovered at a depth of some 38 fathoms. Very clear and sharp pictures of the hull were seen on the television screen in the wardroom of H.M.S. "Reclaim" and the Captain, Lt.-Com. Bathurst, was able to establish that the wreck was that of some merchantman, most probably sunk during the last war.

At a Press Conference after the demonstration, Lieut.-Commander Bathurst said he was confident that the new technique will not only modernise world-wide salvage methods, but also will speed up the work of H.M.S. "Reclaim."

A second and smaller camera for under water use is at present being designed by Pye Limited, for experimental work at the Admiralty Research Laboratories.

Mobile Loading Platform

To facilitate the loading and unloading of railway goods wagons directly from and to road vehicles by power pallet trucks, Lansing Bagnall Ltd., of Basingstoke, have developed a new addition to their large range of materials handling equipment—the mobile loading platform. (Patents applied for.)

This consists of a four-wheel trailer with two platforms of adjustable height, hinged at an intermediate point, which can be raised or lowered by means of a convenient crank handle operating mechanical screw jacks, and a linkage system. At the rail wagon end, the platform remains in a horizontal position at all times and has a vertical movement of 3-ft. 9½-in. to 5-ft. 3½-in. above ground level, with an area of 6-ft. x 6-ft. The road vehicle end has a vertical movement of 3-ft. 1-in. to 4-ft. and forms a sloping platform 10-ft. x 6-ft. which allows it to be used as a ramp. Hinged flaps, three at the wagon end and one at the road lorry end, are provided and act as bridge plates when the platform is in use. In operation, the platform is positioned alongside a railway wagon so that the horizontal platform end is in line with the wagon doorway, it is then adjusted for height, and the hinged flap dropped to form a bridge plate, after which the parking brake is applied. The two remaining flaps are left in the vertical position and act as a safety wall round the other two sides. The road vehicle to be loaded or unloaded is then backed up to the ramp end and the height of the platform adjusted accordingly, while another hinged flap forms a further bridge plate. Palletised unit loads can then be removed by

Manufacturers' Announcements—continued

power pallet truck directly from lorry to wagon or vice versa.

The mobile platform is provided with a tow bar so that it can easily be moved by any vehicle fitted with a standard type of towing bracket. It is so manœuvrable that, should it be necessary, two or three men can move it with ease.

By using the mobile platform, the previous necessity for a loading bay is obviated and the time factor for goods wagon loading is greatly reduced. Other uses for this piece of equipment, are direct transfer of palletised loads from long distance vehicles to local delivery lorries in open yards, for use where no loading bay is available and the expense incurred in building one outweighs its use, and speed of turnround of railway trucks in goods yards by eliminating the need for shunting the various trucks up to a platform. It should also have many uses in speeding up the clearance of cargo from docks and transit sheds.

New Wire Rope Clamping System

Ever since the first wire rope was made, it has been necessary when an eye or join has been required to make a "splice"; that is, unravel a part of the rope (as much as three to four feet in the larger diameters) and re-weave it into the unravelled portion thereby providing the eye or join. And because no machine could be designed that would duplicate the work of human fingers, this work has always perforce been done by hand—a long job especially on the larger sizes of wire hawsers, taking as much as five hours of skilled labour to make one splice at the same time frequently causing damage and injuries to the hands.

The invention of the "Talurit" Wire Rope Clamping System, however, entirely eliminates this expensive and time-wasting handwork for it provides a stronger join than the splice in less than five minutes even on the largest diameter wire rope and uses only a few inches of material to make the join. In other words, what has hitherto taken hours now takes less than the same number of minutes; and what has used feet of material now uses less than the same number of inches. And all this with greater efficiency and strength than the hand splicing method. It will therefore readily be seen that the new method will enable spliced wire ropes to be supplied more quickly and at less cost plus a substantial saving in raw materials. In percentage terms, the saving of raw material is as much as 85%, whilst the saving of time is even greater.

The new system is, primarily, a method of providing splices in wire ropes of all diameters up to 40 mm. in the standard range and up to 60 mm. when necessary by placing two thicknesses of the rope into a Ferrule, placing the Ferrule with its portion of rope into a Press with its appropriate Swage and exerting correct weight/pressure to mould the Ferrule and the two thicknesses of rope into one homogeneous mass and, by automatically changing the shape of the Ferrule, confine the two thicknesses of rope into the same space that normally only one thickness would occupy.

Generally, the applications of the "Talurit" Wire Rope Clamping System is limited only by the ingenuity of industry, commerce and transport using wire ropes or contemplating their use. It is of particular value for users of ship's hawsers, winch cables, tow lines, rigging, lifts, bridges, submarine cable laying, conveyor belt systems, marine salvage, derricks, turn-tables, cranes, winches, etc. Full particulars can be obtained from Cable Covers, Ltd., St. Stephen's House, London, S.W.1.

New Diesel Electric Drilling Barge

Messrs. Ferguson Brothers (Port Glasgow), Ltd., recently launched a Diesel Electric Floating Power Station Barge designated G.P.2, which they have constructed for The Shell Petroleum Co., Ltd. This vessel although not an entirely new departure in the sphere of marine or inland water drilling technique is the first of its type to be designed, built and equipped in this country and has created much interest while under construction.

G.P.2 has an approximate displacement of 2,545 tons and has been built in accordance with Lloyd's Rules and Requirements Class A (Drilling Barge for service on Lake Maracaibo or other enclosed Waters). Her principal dimensions are: length moulded 156-ft., breadth moulded 80-ft., depth moulded to main deck at sides 10-ft., designed draft 7-ft. 6-in. Above the main deck an upper deck extends at a height of 10-ft. practically over the whole structure.

The vessel is of all welded construction and is of rectangular form. The hull below deck is sub-divided into an extensive series of longitudinal and transverse compartments for ballast, water and oil. The main engine room or power house is situated on the main deck aft and is a spacious compartment 70-ft. wide with a length of 37-ft. 6-in. and height of 20-ft. It is entered by 17-ft. wide sliding doors on each side on main deck. A travelling crane, to facilitate machinery overhauls, runs athwartship over the whole engine room.

Forward of the main engine room below deck is situated a large pump room containing two powerful mud pumps which handle the mud flush in connection with the lubrication of the drills. Other special plant is also installed in this space. In conjunction with these pumps a mud ditch system is installed on main deck complete with dual shale shakers-screens settling pits and chemical tanks.

In addition to the power house there is on the main deck a barytes store, core shed, electrician's store, crew's nest and wash-place. The upper deck is arranged for the stowage and handling of drill pipes, casings and tubing and also has an engineers' mess, dressing room, engineers' office and wash-place. Two electric driven 3-ton luffing cranes of 25-ft. radius are also provided here for the handling of drilling gear.

During actual drilling operations the barge is moored by four 7,000 lb. anchors at a distance of 25-ft. to 120-ft. from the permanent drilling platform on the lake and is connected to this platform by flexible cables and control lines. The design embodies arrangements for making it a self-sustaining power unit for drilling operations of over 30 days when used in conjunction with the drilling platform and the drill is operated to depths up to 15,000-ft.

The main electrical generating equipment has been supplied by Messrs. Metropolitan-Vickers and the diesel generating engines by Messrs. Mirrlees, Bickerton & Day. All machinery has been installed by Messrs. Ferguson Brothers (Port Glasgow), Ltd.

G.P.2. was launched with practically all main machinery aboard and the vessel is expected to be completed shortly and being non-propelling, will be towed to destination.